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SCHOOL SCIENCE AND MATHEMATICS

NATURE CLUBS FOR TEACHER TRAINING

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For the past four years student-teachers in Nature Education at Western Reserve University have had the opportunity of practicing nature leadership with a club of adolescent children instead of preparing "daily assignments." During the past semester there were forty-two animal clubs in greater Cleveland that were an adjunct to the course in vertebrate animal study. This meant approximately a thousand boys and girls meeting voluntarily in after school hours at library centers, settlement houses, voting booths, and church basements. This is a radical departure from the more formal method of dissecting pickled cats or the external verbose dissection of live cats which may be just as pernicious. These students are held responsible for all tests but for no laboratory work or daily preparation.

To many of my fellow craftsmen will arise the query as to how anyone dare give credit to a student who is not held responsible for daily assignment.

At the outset it should be stated that the option of club leadership is only allowed those who have had a successful nine week period of training. This means that the students have at least reached the fourth semester. Such students have been rigorously checked as to general scholarship, personality, and physical vigor.

Most biology majors have experience in club leadership. The leader who elects the club route knows that it is up to him to follow it through to a successful conclusion. He cannot drop

the club in the middle of the term for that would mean self-admitted failure. He has to make it interesting enough to attract fifteen boys or girls and having once set the pace he cannot afford to lower his standard for he would then lose his club. For convenience in travel and other inclinations leaders tend to organize a club in their own neighborhood or with their own church or racial group. Each club has a sponsor who is usually a librarian, or a community house director. The sponsor sends a written report at the end of the semester. Club members are ambitious. They want a definite goal such as an animal fair or a garden show. They clamor for field trips. Leaders who make promises to a club are held strictly accountable. The requirements of youngsters are higher teaching standards than one could hope to exact by any other method. The success of clubs in the past and the good will already developed in the locality probably play no small part in the attitude of the leader. To meet a club of lively youngsters requires self-assigned preparation of the broadest sort on the part of the leader who would preserve his self-respect.

Club leadership does require preparation. The leaders will tell you in chorus that it requires more preparation. There is this difference. Club leaders prepare according to their *needs* and not according to any set curriculum. Animal study may lead into unthought of channels. An animal fair was held at the Cleveland Museum of Natural History. Each club was given the opportunity of explaining and answering questions about exhibits that they might select. It so happens that the museum has a notable collection of fossil fish of Ohio. One club signed for this section of the museum. The leader studied monographs and spent two hours with members of the museum staff asking questions that she might get the proper background for training her club members. In the usual course in vertebrate zoölogy the fossil fish of Ohio might easily be passed unmentioned yet they undoubtedly were subjected to the same natural laws and principles that are stressed in the study of the classical goldfish or the type dogfish. The latter method is one of lesson-learning. If learning facts is the objective, and we do not concede that it is, even the most conservative will concede that the club method of electing the experience with fossil fish will result in a goodly collection of factual material. We believe, however, that the facing of a quizzical audience, the

concept of the scientific method, and the growing idea of the immense age of this old earth are much more valuable.

Furthermore there is developed a bond of sympathy amongst club leaders. They feel that they are pioneering and that an exchange of experience is worth while. Word quickly goes the rounds that churning butter and serving animal crackers makes a good meeting. The holding of the toad by each child has significant values but the same procedure with a frog is usually disastrous as the frog will inevitably escape. The leader who "charms" the snake has a definite prestige with the club. There is not only an exchange of ideas but also of materials. One leader purchased a pair of white rats from another club leader who had a surplus. One morning she heard faint squeaks and upon investigation found eleven little ones. She had been told that father rats sometimes eat little ones and that she should put him in a separate cage. The next morning she heard squeaking in papa rat's cage. Lo and behold, papa rat had seven little ones. They were then distinguished as papa-mama rat and mama-mama rat. A good time was had by all.

One must not overlook the fact that children who join an animal club, for example, do so because they are interested in animals. They probably have pets at home. If there is any pedagog who doubts that information is necessary let him walk into a club meeting of fifteen boys with a dish of hatching salmon eggs, or a live bat or an alligator, or take the children to a Live Stock Show. Club members feel free to ask questions. As one leader puts it, "Children *fire* questions." How much is included in that word *fire*. Take the bat for example: Is it a bird? Why does it have fur? Will it suck blood? Why do bats eat insects?

Another consideration is that children who join an animal club are apt to be the children who know the most about animals. Anita did not think that all fish breathe by gills. Fortunate the leader who knows about the lung fish at such a moment. Again Anita asked pertinent questions as to whether flying fish really fly and if there were not fish that walked on the bottom of the ocean. Intelligent questions require intelligent answers.

It is not always the school-repressed children who speak out in meeting but the informality of a club meeting tends to encourage "wild tales." The leader is constantly called upon to

settle conflicting ideas within the club or to tactfully disillude stock notions brought from home. To wit:[1] "One girl told that snakes do not close their eyes until night. (This information came from her father.) It being night I had her watch the snake to tell us when it closed its eyes. She was unsuccessful. I had a snake skin which I had taken to the meeting. I showed her how the snake sheds the skin even over the eye." A leader who took her club to a butcher shop wrote, "I had to admit that I did not know more often than I cared to."

A club leader has to execute judgment as well as tact. Suppose that the leader takes a white rat to the club meeting. In the mean time a club member brings in his new alligator. The thing to do is to reserve the white rat for the next meeting. It is time for alligators. If the conversation lags the leader must introduce a question or "something-to-do" from up his sleeve.

A second question that a teacher in a professional training school may well consider: In what ways does leadership in a club differ from practice teaching in the school room?

Club membership is entirely voluntary. There are no lessons or grades nor is there a curriculum or assignment from above. Each meeting is for an hour or an hour and a half. It is sufficient unto itself although it relates to the main objective of the club. The procedure is wholly informal and often develops into a heated argument. It is usually limited to boys or to girls. The children feel that it belongs to them. They have formed it. They have named it. They have elected their own officers. They keep it going. They can give it up. They have it because they are working together for a common goal.

The club is a gang and the leader is thought of as one of the gang. To quote from one leader: "I brought three snakes. The boys were astonished to see me pick up one of the biggest. One boy declared that I wasn't a boy and in a very polite way told the others that girls were not allowed in the club anyway."

The leader is a gang member but of the big sister or big brother variety. He is thought of as a guide rather than a dictator. He helps solve problems. He has suggestions when they are sought. He knows just the place for a fine trip. He has materials in case of emergency. He sees to it that each meeting is interesting. It has to be so interesting that everyone

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[1] The leaders of clubs keep diaries. I shall quote freely from these diaries.

wants to come again. It has to be so interesting and so snappy in execution that there is no time for discipline.

The size of the group is another important factor. It is urged that the club be limited to a membership of fifteen. This makes for comradeship, and for freedom of speech and action. In the case of animal study each one can get near enough to see the toad eat his skin, handle the turtle, or to take a hand in stirring the cream.

It has often been claimed that anyone who can run a club of adolescent boys or girls can teach but that all teachers cannot run a club of boys or of girls successfully.

Having looked at the general setting of a club we will now proceed to an analysis of the situation keeping in mind the ways in which this particular experience of leadership is in keeping with the so-called new-type education.

1. *Advertising for members.*—After selecting the club meeting place, one of the first things for a prospective leader to do is to advertise for members. This often leads to ingenious steps. The usual way is to make a poster. One leader who had a special aptitude for art asked each candidate for membership to bring his best sketch of an animal. As a result she had thirty-five candidates to select from for her animal-art club. Another student went to a settlement house and had no applicants. She took her snake to the game room where a score of boys were busily engaged in all kinds of contests. She soon had an audience. They began to ask questions. She refused to answer any questions but said that all who wanted to know about the snake might come with her to the animal club room. Some leaders go into the schools of the neighborhood and speak to the fourth, fifth, and sixth grades. Oftentimes only one child appears at the first meeting and then again "twenty-seven boys rushed into the room and sat on the sewing machines and window ledges as well as the chairs." Another writes: "We went on a brook trip to see what we could find in the way of animals. We started with seven boys but by the time we reached our destination we had twelve. The original seven were so enthusiastic and beaming that they infected five more." The following is the usual report: "When I went to the library for the second meeting I happened to get there a little after 3:30 and all of the children were there. Our meetings usually begin at 4:00 P.M. There were three times as many children as at the first meeting."

Woe as well as joy often follows the membership. One leader took her boys to the Animal Fair. There were over 3000 children milling around. The film was shown four times and the promised dog performance had to be omitted. One gang of boys blamed the leader because Rex did not appear on the program. "Their spokesman, with his cap cocked over one ear, told me in any but a gentle manner that they were through. This made me feel like 'giving up the ship' but with the vision of Perry before me such was impossible."

2. *Naming the club.*—To the uninitiated the naming of a club may seem a mere trifle. Such is not the case. The tribal idea is deep in our nature and the desire to initiate is also an ancient impulse. One leader was worried because the boys wanted to call themselves the "Pacing Mustangs." I assured her that she had possession of a powerful symbol for character building and gave her a copy of *Wild Animal Ways,* by Ernest Thompson Seton, which contains a story of "Coaly-bay, The Outlaw Horse." I suggested that that be her story for the next club meeting. Coaly-bay, just as all live boys, had red blood which every once in a while seemed to show power and the eternal love of freedom.

"When I suggested that we get a name there was an awful silence. 'Students of Nature' was suggested. Harold volunteered that that wouldn't do as it sounded too much like school. 'Seekers of Wisdom about Nature' was the next best offer. Where did they get these inspirations? Clarence suggested that we take the first letter of each word which would give us 'Sowan.' Everyone became enthusiastic. They accepted the name and decided that only the members were to know the meaning of the name."

Another leader showed self restraint and good sense when she reported that "The Star Pep Club" was the name we chose today for our animal club. "It isn't very striking to me but the boys think that it is just great." But what name could better represent a higher aim or the spirit of go? No leader would want a group of boys who named themselves the "Pansies."

3. *The election of officers.*—Here, too, a leader must follow a hands off policy. "The boy whom I consider the best leader didn't receive an office. To my surprise the boy whom they chose as president seems like a bully. Undoubtedly I don't

know him as yet." Often the leaders are complimented as follows: "One of the boys nominated me for the honorary position of president. Before I could say a word they all agreed. Of course I had to refuse the offer as I was only the guide for the club."

The leader must also sense when it is time for election. Many leaders do not have election until the second meeting. "First Meeting: Only two boys. I had a toad but the boys called it a frog. Still it was a toad. Second Meeting: I entered the club room. I felt weak. What would I see? Oh there were five boys. What a relief. I felt better. We had our election. Philip Michael Patrick O'Dwyer was our president. The secretary was Joe Kovack. And can you imagine it? I was elected the treasurer. I was informed that no one else could be trusted. So between the toad, two charter members, and three new members we had a successful meeting. I believe that I am going to like it."

Another leader did not have the election of officers until the eighth meeting. Here are significant items from her diary: "October 10; I was eager to see how many people had been attracted by my signs. An eleven-year-old girl came. October 17; Only Gertrude and her friend Elaine came. October 24; Hurrah! Four members today. October 31: By the end of the meeting I had 24 children there." Clubs almost invariably select good officers. Their democratic method is to be commended. They are just as decisive in reducing incompetent leaders to rank. "Some of the members were saying 'He's too silly. He ought to set an example for the rest of us.' I then asked Moses if he knew what happened to kings when the people were dissatisfied? He said that he understood, so the matter was dropped." It was not until the sixth meeting that Moses was deposed.

4. *Club rules.*—Club rules should be few and should emanate from the members as the occasion arises. In the old-time school the need for discipline arose from the difference in points of view between the teacher and the children. We now know that if the children are given interesting things that there will be no problem of discipline. Action rather than words is the best psychology.

"A teacher sent a note today for me to keep an eye on several boys as they were discipline problems at school. As yet I haven't seen anything to complain about other than their

being a little noisy or rough now and then. Nick, who is our president, is doing a good job. He conducts meetings as though he had been doing it all his life. Another, Peter, has suggested that he bring his fish bowl.

"It was several meetings after this that Peter resigned in a huff. He demanded his fish bowl. The club requested a week's notice. This was for the simple reason that the fish have no other home. We felt as important as the banks that demand 60 days' notice. Peter consented to call for it next week. The boys passed a rule that no new members would be admitted who would not hold a toad, a snake, and a turtle.

"On the field trip today I had 35 peppy youngsters. We found an ideal place to cook. Little did we anticipate the East Dennison gang, who have a reputation for being the roughest gang this side of the river. In the space of five minutes we had quite an audience. They did everything possible to annoy us. They set two enormous playful police dogs cavorting around to snatch any wieners that could be found. They set fire to the tall grass nearby. When they found that we weren't afraid they stopped."

5. *The club method is the "doing method."*—It is true that the club method can be used in school but not equally true that school methods can always be carried into a club. Leaders of clubs soon become conscious that if their plans contain words ending in *ing* that they are more apt to become successful. School classes can well take their inspiration from the enthusiasm of after-school clubs.

"Last week we had two turtles. The children placed them on the floor and let them make an attempt at *racing.*" Nothing educational about a terrapin race you query? That would be difficult to prove. The preaching method in Sunday School didn't prove to be very efficacious when it came to educational tests and measurements. It is no longer safe to take anything for granted. At any rate, a safe rule in club work is to let the activity start with the child.

"When the boys and girls saw the toad they all wanted to see it jump. When I started to take it out of the jar a boy asked if he could do it. Then everyone wanted to hold it. One girl was afraid of getting warts and said so. The boys laughed. The girl accepted the challenge." The leader, but not the children, recognized the *handling* of the toad as an experience in atti-

tude and a step to do away with superstition. This is a major objective in any science.

"We had our meeting in a portable school building. It had not been cleaned for months. One of the boys found a moth flitting about. It was nearly as large as the frog. We wanted to try *feeding* him to the frog. There was quite an argument as to whether the frog could really down it. The frog settled the question by grabbing the moth and gradually shoved it in with his chubby hands. The boys were thrilled." Leaders should listen hard for ideas born of inner urgings. They make excellent working capital. The children are not merely entertained. They work better as self-starters rather than by the cranking-up process.

"The children seemed a little disappointed today for I had no animal. When they found that our discussion was to be about *going* to the pet show and that they could commence *planning* their part they were at once interested. The meeting was earnest and business-like. The discussion included: Why going? How go? How get the money? What our responsibilities were? How find materials for talks? Who should talk?

"I found them a little impatient. They were *waiting* for me in the rain. Tony had been standing there a whole hour. He confided that his mother had made a special trip to the Associated Charities to get him some clothes so that I wouldn't be ashamed to take him. There were many patches but Tony was entirely presentable with an almost brand new cap two sizes too large. I was ready to weep at the little story. Ruth told me that she had been *lecturing* all night on the garter snake. Her mother had awakened her several times in order to stop her. Edward had slept with his father's watch under his pillow so as to be sure of *waking* up in time." A club at its best is the center of responsibility. It connects up with the home and the neighborhood.

"We had a special meeting today to get ready for our Animal Show. They were busy *bringing* chairs down to the basement, *hammering*, *hanging* signs, *roping* off a center ring, and *arranging* home-made cages. Brothers and fathers came down in case we needed help. We put them to work too." An industrious club is a well-managed club.

Another leader reported that her best meeting was when they were *making* fruit jar aquaria. Her father had taken her

to a pond where she obtained a goodly number of catfish and Johnny Darters. She had a pail of sand and an abundance of water plants. Each member was to bring a fruit jar. Those who forgot them were glad to run home and get one. The leader demonstrated how to wash the sand and set up the aquarium. She answered all questions and then each one set to work. The aquaria were to be sold at a street fair. The leader said that she was well repaid for all the time that it took to get ready.

6. *Club leaders emphasize accomplishments rather than grades.*—The leader has to realize that accomplishment comes step by step. It is a gradual building up. It is an every-meeting code and not a pose on exhibition day. Perhaps a member brings in a newspaper clipping of a dog that has saved a life. A word of recognition from the leader may bring a series of clippings that pertain to the appreciation of animals.

A little colored girl wanted her leader to take the garter snake across the street to show her mother. On the way they met a small boy who said: "Le's put 'em on de cah track." Nellie retorted: "Gwan away! How'd you like yo neck on de street cah track?" In this instance perhaps silent commendation would suffice.

The leader who lends a keen ear will hear sentences that carry a world of goodness. A boy told me one day that "I am going to keep one puppy. He looks like his mother." Another boy brought his dog to the dog show. When anyone showed interest he would say: "This is a clean cut dog." He won first prize for having the cleanest and best taught dog yet he belonged to a gang that had been stealing bicycles, repainting them, and selling for a small profit. His father had brought him to school and seen to it that he went in the front door. The boy would then slip out the back door and was away for the day. "A clean cut dog." What a foundation for building right attitudes and habits!

Another ragamuffin found that the breakfast food had become wormy. His contribution was meal worms for the club toad. Everything is gold that comes to the club leader's meeting. Perhaps it does not glitter but it is worth mining.

"We tried to feed our turtle but did not succeed. Alice had read a story of a little girl who had a turtle and had endeavored in every way to make it happy. She could not get it to eat

and let it go. The club asked if they could let the turtle go after the meeting so that he would be happy. I was very glad to comply with their suggestion. I was not sure whether it wanted lettuce, whether it was a carnivorous species, or whether it was just natural for it to refuse to eat because hibernation days were here but I thought that my children had gone a long way when they really wanted to take it back to its natural home. I hope that I decided wisely."

Perhaps the final test of humaneness came when several hundred club members went to a moving picture presentation of the White-Fuller expedition to Africa. In one scene the drivers hit the camels to get them to move across a stream. One could sense that the audience caught its breath and a murmur of resentment swept over the young spectators. I knew at once that one objective of animal study had been accomplished. There was no need of a written examination on humaneness. The answer had been given.

One leader felt complimented that someone stole the club turtle. She said: "At last someone is interested."

"Harold Mueller, who had been guide at the Animal Fair, had his picture taken which appeared in the Rotogravure section of the *Plain Dealer*. He was holding his friend, the opossum. Harold has received two letters from owners of opossums. The writers wished to get information on how to care for opossums. The boys composed letters and mailed them after the meeting. They wanted to know if our meetings couldn't commence at 3:45 instead of 4:00 P.M. I feel that I am winning. It's lots of fun."

7. *Accomplishments are not limited to individuals.*—"We made an aquarium for the library tonight. The boys donated their largest and prettiest marbles along with a few shells. Some of the boys made a chart of the aquarium so that the children would know its contents. We elected a committee to present it to the librarian but the whole membership went with them."

Girls enter co-operative undertakings as readily as boys. "My children want to have a pet show. They have already enlisted their parents to help make cages. The idea came from the children and it is all voluntary. In fact I have to run to keep up with them. I learn a lot. It is really a fifty-fifty proposition. Some of them are getting talks ready for the mothers' club."

Anyone who has seen the glow of faces as they make these natural accomplishments will readily see why artificial rewards are tabooed in club work.

8. *Club experiences mean education from within.*—"We had three new members at the last meeting. One of them walked to the street car with me. He told me that he belonged to a nature club at school, but that it was awful. All they talked about was 'leaves and stuff.' He said that 'He liked to study about snakes and real things.' Of course I did not tell him that leaves are real. I am going to double my efforts to make things interesting. And besides I am determined that it will be the boys' club. He also said that his school teacher and his mother were afraid of snakes and he couldn't understand why I wasn't afraid of snakes."

Education from within applies to leaders as well as members. One leader recorded in her day book as follows: "I took a black snake to my second meeting. I had not intended to pick it up, but when I got there I mustered up all my courage and the snake curled around my hands. It wasn't half bad.

"I was presented with a dog today. I am to call him 'Sowan.' Oh what a surprise. A little puppy. 'A German police dog and something else,' James said.

"Meriel came last week with pictures for the bulletin board, a wagon containing waxed autumn leaves, a bowl with two goldfish, three toads, and a box of loam to help fill the terrarium we are building. With the interest the children are showing the terrarium should turn out quite well."

9. *Nature clubs lead afield.*—A nature club that always meets in a room is not a real nature club. Boys and girls have come to expect that at least 20 per cent of the time will be given to field trips. Club members enjoy adventure and roughing it. Observing, legitimate collecting, and taking pictures as they go are the usual activities. The all-day hike should include cooking out. It is important for leaders to get the permission of the parents, to see that the children are properly clothed, and to carry a first aid kit.

"We went to the Zoo and carried lunches. By dark I suggested that we start home. The boys wanted to climb the steep hill. I gave them a chance to vote and they all wanted to go. On the way down the hill one boy started to run and couldn't stop. He fell and cut his knee. I thought of the men working

on the Fulton Road Bridge and that they must have a first aid kit. The man said that he must go to the hospital immediately. The boy was sure that his leg was broken. The man finally offered to take the boy home. I hardly knew how to thank him, or how to explain to the parents. Neither parent got excited and they were fine about it. The doctor took three stitches."

10. *A good meeting includes the play spirit.*—A generation ago no one suspected that there could be any good in "Hoss Play." Today we are not so sure. Some have come to believe that the game method is one of the best ways of instruction. Tracking animals and interpreting animal tracks is great fun.

11. *Conclusion.*—What about the days to come? Will I keep on with clubs as a means of preparing students to teach nature study in the elementary grades? At the present time I cling to the idea that the club is one efficient way of teacher training. It is not the only method. At present the club is a more satisfactory medium than many training schools.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE

By DUANE ROLLER,

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There is hardly anything in this world that some men cannot make a little worse and sell a little cheaper.—*John Ruskin.*

At the present moment light is the darkest of the physicist's problems.—*Arthur H. Compton, American physicist, in "The Scientific American," February 1929.*

Freedom from the necessity of servants due to mechanical household aids is the best feature of American life.—*Albert Einstein, quoted by "Time," March 14, 1932.*

To appreciate the living spirit rather than the dry bones of mathematics it is necessary to inspect the work of a master at first hand. . . . The very crudities of the first attack on a significant problem by a master are more illuminating than all the pretty elegance of the standard texts which has been won at the cost of perhaps centuries of finicky polishing.—*E. T. Bell, in "The Queen of the Sciences."*

Abel, one of the greatest mathematical geniuses of all time . . ., asked how he had done all this in the six or seven years of his working life, Abel replied "By studying the masters, not the pupils."—*E. T. Bell, in "The Queen of the Sciences."*

A FEW UNCERTAINTIES IN THE HISTORY OF ELEMENTARY MATHEMATICS

By G. A. MILLER

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1. *The term algebra.*—There are few terms in elementary mathematics about which so many conflicting views have been published as about the term algebra. All writers on the subject seem to agree now that this term can be traced back at least as far as to the title of a work written in about 825 by a Persian mathematician named Mohammed ibn Musa, Al-Khowarizmi, but differences of opinions relate to the meaning of the part of this title which gave rise to the term algebra. Among the various transliterations of this title is the following: *Al-jabr w'al muqabalah.* One of the most common translations thereof is "restoration and opposition."

A singular fact is that somewhat different meanings have commonly been assigned to the two terms *al-jabr* and *al-muqabalah.* On the contrary, Professor O. Neugebauer of Göttingen, Germany, has recently supported the view, expressed several years ago by Professor S. Gandz, that the latter of these terms is merely the Arabic translation of the former which is an Assyrian word and means an equation. If this is correct the term algebra is derived from a word which means an equation instead of from a word which means that an equation involving positive and negative terms is so transformed that only positive terms appear therein, as is commonly stated in our histories of mathematics and elsewhere.

What is perhaps of greatest interest in this connection is the fact that an explanation of the meaning of the word algebra which now seems to have no foundation has found its way into many of our best works of reference, and it will probably take many years before this error will disappear from the then current mathematical literature. Fortunately this change will tend also to simplify the history of mathematics since the concept of equation has always played a fundamental rôle in the development of algebra while the operation of transforming an equation which involves positive and negative terms into one which involves only positive ones is now somewhat trivial. This transformation was emphasized by Diophantus

and appeared less trivial to the Greeks and the Arabs than it does at the present time in view of the fact that the concept of negative numbers had not been mastered by them.

In an article published recently in the periodical entitled *Quellen und Studien zur Geschichte der Mathematik-Quellen,* volume 2 (1932), page 1, Professor O. Neugebauer stated that an Assyrian word which is equivalent to *al-jabr* appears very frequently in the wedge writings with a meaning similar to that of equation. On the contrary, no good evidence has been produced to support the common view that this term ever stood for the transformation noted above. Such recent discoveries relating to the title of an old and fundamental branch of elementary mathematics exhibit the fact that up-to-date knowledge on the history of mathematics cannot always be found in the textbooks on this subject but that this history is now growing just as other parts of the mathematical sciences and various of its most recent developments appear first in the journals.

2. *Oldest extant mathematics.*—In the periodical noted above Professor O. Neugebauer calls attention also to the fact that the ancient mathematical texts which have been deciphered usually are not dated, and hence there is a considerable element of uncertainty as regards the time when they were written. He concluded, however, from other evidence that a text which he published therein is the oldest known text which embodies a considerable amount of ancient Babylonian mathematical lore, and it is surprising to find that this text stands also on the highest mathematical level among those which are now known and relate to the ancient Babylonian or Egyptian mathematics. It is important to note here that he emphasizes the conclusion that this most ancient mathematics is *pure* mathematics and does not seem to have been cultivated on account of its use in astronomy or in the commercial transactions of that time.

This is a point which is naturally of great interest to the teachers of mathematics for it is likely that the elements of our subject which appealed most strongly to those who first cultivated it will also appeal strongly to the modern student when he first becomes acquainted with some of their properties. There probably have always been wide differences between students in this respect and the modern student of mathematics

is doubtless more deeply impressed by the need of a good scientific equipment to cope with the stern realities of life than was the case with the students of this subject in the earlier civilizations. At any rate, it is interesting to note that mathematics seems to have been cultivated for its own sake even in the oldest now known literature relating to this subject notwithstanding the fact that the practical nature of early mathematical developments has frequently been stressed.

One of the striking features of the partial solutions of quadratic equations which appear in the ancient Greek literature on this subject is that only one root was considered therein even in the cases when both of the roots of such an equation are positive. Hence the fact that in this most ancient extant mathematical text the two roots of such an equation are sometimes given is of special interest. It is also interesting to note that the solution of the quadratic equation was considered in special cases so early in the development of algebra, especially since the complete solution of this general equation depends upon the use of negative and complex numbers, and a satisfactory theory of these numbers did not appear before about the beginning of the nineteenth century.

The history of algebra has been greatly extended during recent years especially by the discovery of ancient Babylonian developments along this line. Hence it is the more interesting to learn from the article to which we referred above that we may expect to have some additional new information along the same line. It seems that the ancient Babylonians used various algebraic methods which were heretofore supposed to be of much later origin and that in this respect they were far ahead of the ancient Egyptians. It should, however, be noted that their mathematics differs widely from that of the ancient Greeks. This difference is due not only to their emphasis on algebra, while the ancient Greeks emphasized geometry, but also to their lack of general proofs. The fact that they solved quadratic equations in accord with general modern formulas is obviously no conclusive proof that they actually knew that these formulas are universally true even when only positive rational numbers are involved.

3. *Division of the circle into 360 parts.*—A considerable number of different hypotheses have been published relating to the origin of the division of the circle into 360 equal parts

now known as degrees. The view most commonly expressed is that this division originated in the ancient Babylonian countries but that the exact time when it originated is not yet known. The following contrary view may serve to direct attention to some of the difficulties involved. "The Babylonians divided the circle into 8, 12, 120, 240, and 480 equal parts, but not into 360 such parts. Thus in a tablet from the palace of Sennacherib (c. 700 B.C.), now in the British Museum, the division into 480 parts is given. It is true that six-spoked wheels are found represented on Babylonian monuments, but no more frequently than the eight-spoked wheels, and the six-spoked type is more common in Egypt where the number 60 was not used to any great extent. It would seem, therefore, that the number 60 was not derived from the division of the circle into six equal parts."[1]

On page 41 of the periodical to which we referred above the Babylonian division of the circle is considered anew and the conclusion is reached that this division was obtained from the division of the day. The day was divided by them into 12 equal parts called *beru* and each *beru* was divided into 30 parts called *us*. It is emphasized here that the 360 division of the circle was not the only one used by the ancienct Babylonians. In particular, they used also the division into 480 equal parts as well as the division into 240, 120, and 60 equal parts. This is an instance of the operation of successive halving. While the sexagesimal positional number representation extends beyond the ancient Babylonian literature into that of the Sumerians yet it has not been established that the latter had completely developed this system including the writing of fractions in the sexagesimal scale. In fact, a fully developed sexagesimal system in the sense that 60 distinct number symbols are used to represent the first 60 natural numbers has never been used by any nation as far as is now known.

One of the greatest difficulties with which the student of the history of mathematics has to contend is the lack of uniformity. For instance, while the numbers 6, 10, and 60 play a prominent rôle in the mensuration of the ancient Babylonians and the Sumerians, they are frequently replaced therein by others such as powers of 2. It is natural that at a time when communications were very limited widely different mathe-

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[1] D. E. Smith, *History of Mathematics*, volume 2 (1925), page 230.

matical practices were established even in communities which were not widely separated. Hence it could have been expected that the division of the circle into 360 equal parts was not universally adopted by the various Babylonian writers even after it had found favor among some of the leading ones. It is possible that the ancient Egyptians had a part in the general adoption of this division of the circle. At any rate, various uncertainties remain to be cleared away before the history of this subject will be satisfactory if this situation will ever be reached.

In view of these facts the quotation noted above may raise serious questions on the part of the reader as regards the reliability of different writers. These questions are likely to become more pertinent if we add here the substance of the following remarks by J. Tropfke, which appear on page 54, volume 1 (1930), of his noted *Geschichte der Elementar-Mathematik*. Old Babylonian war chariots had six spokes, not four as in Egypt and Greece. Chariots with six-spoked wheels are first pictured in Egypt about 2000 B.C. in representing Asiatic tribute. The Babylonian wind rose does not exhibit the fundamental number 4 as with us (32 lines) but the number 6 (36 divisions). By halving the divisions into 6 parts there resulted a division into 12 parts; the Babylonians used this not only in the division of the circle but also in the measurements of lengths, and extended it later to the divisions of the day and night. The oldest scientific division of the day is into 6 chief parts *us;* the surface of the sun clock on which the shadow of a stick appeared was divided into six principal angles. When greater accuracy was required later each of these was further divided into ten parts giving rise to the day of 60 hours.

4. *Misnomers.*—In the preface of the first edition of his well known *Geschichte der Elementar-Mathematik*, J. Tropfke called attention to the desirability of banishing from the teaching of mathematics such incorrect terms as Diophantine Equations, Cardan's Formula, Golden Section, Hudde's Method, Gauss's Number Plane, and many others which have become deeply rooted in the mathematical literature. On page 180, volume 2 (1921), of the second edition of this work it is stated that the use of the term Napier's logarithms for natural logarithms, as is done regularly at the present time, is entirely incorrect. It would be easier to justify the name Bürgi's logarithms for the latter since by inserting the decimal point suit-

ably we can secure an agreement here at least to three decimal places. This name would, however, not be entirely correct because the natural logarithms entail considerations relating to the infinite which were entirely unknown to Bürgi as well as to Napier.

From these remarks of J. Tropfke it results also directly that the common statement that J. Speidell constructed a table of natural logarithms, which appears, for instance, under the term "logarithms" in Webster's *New International Dictionary*, 1927, is open to objections since the tables of J. Speidell were based directly on those of J. Napier. One objection to such statements is that they are in disaccord with the natural inference that the base of the natural system of logarithms was known when these tables were constructed. The possibility of securing historical knowledge by inferences from given facts should be maintained as far as possible since this constitutes the easiest method for making rapid progress in this subject. Under the term "trigonometric" in the same dictionary there appears a figure in which the names of the second and the fourth quadrants are interchanged and the abscissa of a point in the second quadrant is said to be positive.

As evidence of how difficult it is to cleanse the elementary mathematical literature from historical misnomers we may cite the fact that J. Tropfke himself uses even in the third edition, volume 1 (1930), page 120, of his cited work the term Diophantine Equation in the sense to which he objects in the preface of the first edition as noted above. Notwithstanding such lapses on the part of leading mathematical historians the theory that the mathematical literature should be purged from terms which imply inaccurate historical situations is commendable. Such terms as Ferro's Formula in place of Cardan's Formula and the Wessel's Number Plane instead of Gauss's Number Plane are steps in the right direction even if progress along this line is discouragingly slow.

A somewhat remarkable statement as regards present tendencies in elementary mathematics is that "certain countries, including those of Scandinavia, tend to denote subtraction by the sign $\div$."[2] It is surprising to find that some Scandinavian writers have used this sign for subtraction even in the present century and that the use of this symbol for this purpose ex-

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[2] Vera Sanford, *A Short History of Mathematics*, 1930, page 147.

tended over a period of more than four centuries. Fortunately this use seems to be decreasing and hence it does not represent a tendency which is contrary to the modern trend towards uniformity in the use of mathematical notations. Judging from the recent volumes of the Scandinavian Congresses of Mathematicians the leading mathematicians of the Scandinavian countries use the symbol — for subtraction just as in other modern civilized lands.

The term "Pythagorean Theorem" is probably a misnomer, since it is not known that Pythagoras contributed anything towards the development of this very fundamental theorem. In recent years various problems have become known in which the ancient Babylonians used this theorem. It is not likely that they actually proved it but there is also no substantial evidence to show that a proof of it existed during the lifetime of Pythagoras. According to J. Tropfke's work quoted above, volume 7 (1924), page 47, "Pythagoras deserves unquestionable credit only for the theorem that six regular triangles, four squares, and three regular hexagons fill the plane about a point." Recent students of the history of Greek mathematics have generally given much less mathematical credit to Pythagoras than was formerly done. The Pythagorean theorem is sometimes called the square theorem of the right triangle but it does not seem likely that the former term will be abandoned in the near future even if it is somewhat misleading.

Historically the term natural number for the positive integers is a misnomer. The number concept arose in connection with counting and it is just as natural to count parts as it is to count entire units. The naturalness of common fractions is seen in the very ancient special symbols for such fractions as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, and $\frac{2}{3}$, as well as in the fact that we now use one-half instead of one-second. The emphasis on the positive integers is largely due to the ancient Greeks and seems to have arisen from theoretic considerations and not from natural or physical ones as the term natural number seems to imply. The ideas that a common fraction is the quotient of two integers, or is a pair of integers, with which one operates according to certain prescribed laws of combination are comparatively modern.

SOME APPLICATIONS OF THE PHOTRONIC CELL

By G. A. Shook and Barbara J. Scrivener
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The simplicity and accuracy of the new Weston Photronic Cell may bring about a change in all photometric measurements. It furnishes a good introduction to the photoelectric method in general and while this type of cell would probably not be used for work where high accuracy is required, the average student can obtain better results with it than with optical methods. When we take into account the time required to match photometric fields, the cell is far superior in every application.

Such an instrument, of moderate accuracy, by means of which an observer may obtain a large number of readings in a short time is often more practical than a precise one which requires considerable care and time. To illustrate, the authors had occasion recently to check up the lighting in the college library and they were able to make a complete survey of the four floors in less than an hour with a Weston photronic illuminometer. Since a reading can be made in a few seconds, it was possible to place the target on the book or paper of some student and thus determine the actual illuminating conditions under which the students are constantly working. In some instances, it was discovered that students, who were some distance from a well lighted table, were reading with an illumination of less than 1 ft. candle. Even if this method does not agree with the optical methods within 10 per cent, it is the most feasible one for such investigations.

A number of students' rooms were also investigated. As the measurements required very little time, every usable spot in the room could be tested. Moreover, in making a change in the lighting equipment, the new conditions can be tested at once with such an instrument.

The model 594 cell was used to measure gloss, concentration of turbid and colored solutions, and reflection factors.

In determining the concentration of a colored solution, a very simple arrangement of cell, lamp, and galvanometer will yield results comparable to the Duboscq type of colorimeter. In the first arrangement used by the authors, the Photronic cell was placed at one end of a light tight box which was provided with a movable 6 volt automobile lamp. The glass cell containing

the liquid was placed in front of the photronic cell which was connected to a Leeds and Northrup Type P galvanometer. In measurements of this kind, a calibration curve may be obtained from a number of solutions of known concentration. In this arrangement, the lamp may be fixed at some convenient position while the galvanometer deflections may be taken as a measure of the concentration or the lamp may be moved back and forth to produce a constant galvanometer deflection. The concentration may then be plotted against deflection or scale reading.

In order to eliminate the necessity for keeping the lamp current constant and also to devise a null method, the writers tried two cells in series with the galvanometer so that they would act differentially. This arangement did not prove satisfactory owing to the shift of the zero. This was not surprising as the resistance of this type of cell changes rapidly with a small change in lamp intensity (for values below 20 ft. candles). The two cells were then connected in parallel but with no better results. The Weston Electrical Instrument Corporation was then consulted and they suggested shunting the two cells with a high resistance. This proved quite satisfactory.
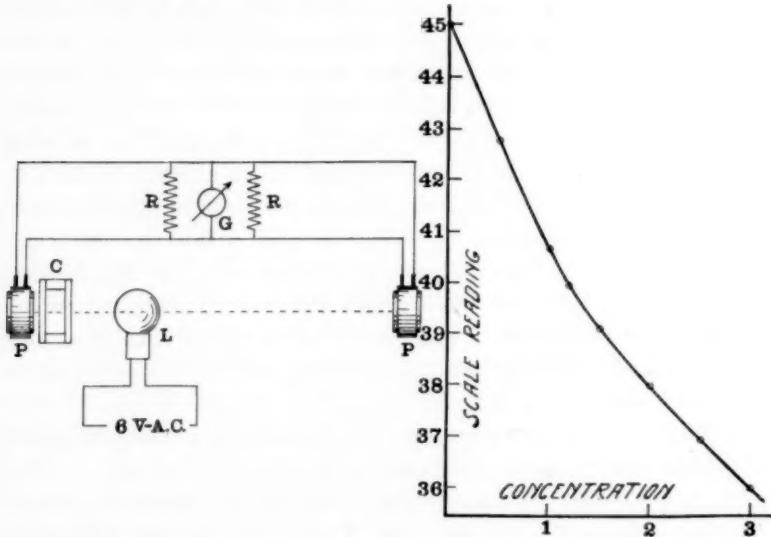

FIG. 1. DIFFERENTIAL PHOTRONIC METER WITH A MOVABLE LAMP, L.

The connections are shown in FIGURE 1. The automobile lamp L is connected to a 6 volt transformer which may be run

on any commercial A.C. circuit. The lamp is attached to a scale, not shown, so that the distance from the lamp to one of the cells may be determined. The two cells, P and P, are 100 cm. apart. As the lamp filament is small, the inverse square law will hold approximately for distances as small as 10 cm. The two resistances, R and R, were each 1000 ohms. If a calibration curve is obtained from a number of standard solutions, it is not necessary to know the exact distance from lamp to cell or the distance between the cells, P and P. A calibration curve from five known solutions of cobalt chloride was determined as follows. The glass cell, C, with distilled water was placed in front of one of the cells as shown and then the lamp was adjusted until zero deflection obtained. This scale reading corresponds to zero concentration. A reading was then obtained for 0.5 per cent, 1 per cent, 1.5 per cent, 2 per cent, 2.5 per cent, and 3 per cent solutions in the same manner, as five or six solutions are sufficient for a smooth curve. A number of calibration curves were determined by several students but it was found that they did not agree upon the initial reading, i.e., for water, although the difference in reading for a given solution was always the same. To produce a standard curve, the scale was then set at some particular value, in this instance 45.00 cm, and one of the resistances was adjusted until the galvanometer showed no deflection. The writers then obtained a calibration curve by this method, namely by bringing the deflection to zero, for water, by means of one of the resistances. The increase in resistance was never more than 7 ohms for either side. This curve was then checked by a number of students with three solutions. They agree within 2 per cent which is somewhat better than they could do with an optical instrument. With a constant lamp current and a more sensitive galvanometer greater accuracy could undoubtedly be obtained but this would defeat the object of this circuit, which was to eliminate storage cells, ammeter, and rheostat.

Instead of a movable lamp, a photographic wedge may be used as shown in FIGURE 2. The wedge, W, was furnished by Eastman Kodak Company and may be obtained in various sizes and densities. The one we used was 20 cm. by 2 cm. and had a maximum density of 2, which means that a transmission factor as low as 1 per cent may be measured. In this arrangement, the effective area of each cell was cut down to an aperture of $\frac{3}{4}''$ diameter to accommodate the width of the wedge and to

utilize small cells. Three solutions, 1 per cent, 2 per cent, and 3 per cent, were sufficient to obtain a smooth curve in this case. A longer cell could also be used to increase the range of scale reading for dilute solutions.
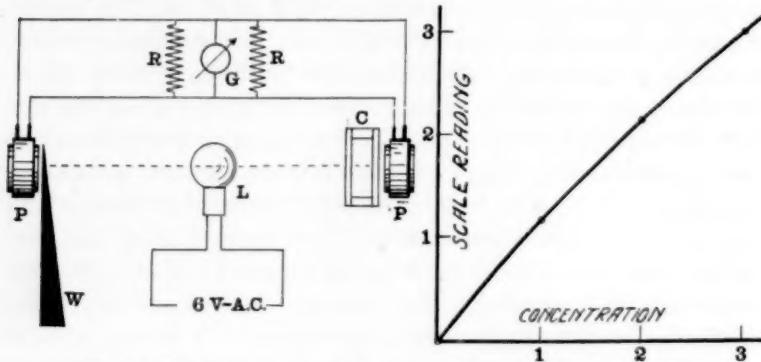
FIG. 2. DIFFERENTIAL PHOTRONIC METER WITH WEDGE.

In order to measure gloss, the sample to be tested is illuminated by a parallel beam at 45° to the normal, as shown in FIGURE 3. A 6 volt automobile lamp, L, and a 1.5″ lens with a focal length of 2″ constitutes the illuminating system. The light reflected into the photronic cell, P, is limited by a tube 1¼″ in diameter and about 10″ long. The cell is connected to a type P galvanometer, although a less sensitive galvanometer may be used for approximate results. The tube and cell are mounted upon a rotating arm so that the illumination can be measured in two positions; normal to the sample and at an angle of 45° as indicated. The two galvanometer deflections, thus obtained, will give a measure of the gloss. The angle Φ is filled by the illuminated area in each position. In the 45° position the deflection will, of course, be larger, depending upon the gloss of the paper.

This method is more sensitive than the optical one and necessarily more rapid. In the 45° position, the cell integrates over a range of about 10° with the result that the illumination in this position is not as high as it would be in the optical method. With papers of high gloss the two methods will, therefore, not agree. This method, however, gives a measure of the gloss which can easily be reproduced and for many purposes it would undoubtedly be preferable to an optical one. As the arm can be changed readily from one position to another, several values

for each position can be obtained in a comparatively short time so that the lamp can be operated on any A.C. circuit. More consistent results can be obtained by keeping the lamp current constant but for approximate values this is not necessary. A distribution curve of the reflected light can be determined from $0°$ to $45°$, but for angles greater than $45°$ the projected area of the illuminated surface will not fill the angle Φ. The maximum of this curve will, of course, be lower than the maximum obtained by the optical methods.
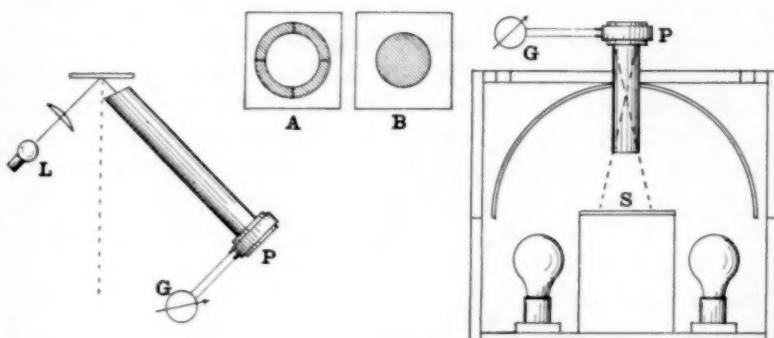
FIG. 3. GLOSSOMETER AND INTEGRATING SPHERE.

Reflection factors for neutral papers, paints, etc., may be obtained with the apparatus shown in FIGURE 3. The hemisphere is illuminated by four frosted 40 Watt lamps so that the sample to be tested, S, receives light from practically every direction. There are, naturally, various ways in which this condition can be realized, but the one shown is sufficiently accurate for most purposes. The sample, S, is placed upon the support at the center of the hemisphere, the interior of which is painted with a flat white paint. The tube limiting the light which enters the cell extends $3''$ below the top of the box as shown. In this instance, the cell integrates over a range of $20°$ which is manifestly more desirable than otherwise. The radius of the hemisphere is $7''$ and the sample must be about $3''$ in diameter to fill the solid angle produced by the tube. The cell is connected to a Type P galvanometer as before. A reading of the galvanometer is taken with a standard white surface, say magnesium oxide, and then with the sample in question. The reflectance can be determined from the ratio of these two deflections. In the case

of a paper of low reflectance, say 50 per cent, a large error will obtain as a result of the light that is reflected into the hemisphere from this relatively large area (about 7 sq. in.). The reflecting area S contributes more light to the hemisphere when the standard white is in position than when the low reflecting paper occupies the same position. In making measurements with integrating spheres an error, too large to be neglected, will result unless the area of the sample to be tested is very small compared with the total area of the sphere.[1] This error may be compensated, to some degree at least, in the following manner: in obtaining the reading for the standard, the paper to be tested is first placed on the central support and then a thin metal plate, A, with an annular opening is placed over the paper. The plate A is just large enough to cover the support and it may be replaced by a second plate, B, which also just covers the support. The inner disk in this plate A is 3″ in diameter and the opening in plate B is likewise 3″ in diameter. Moreover, the annular ring in A has the same area as the opening in B, which is, of course, equal to the area of the disk in A. Both plates are painted with the same white paint as the hemisphere, but the inner disk of A is covered with magnesium oxide and this serves as the standard.

A galvanometer reading is first taken with plate A over the paper to be tested and this reading is a measure of the brightness of the standard. The paper is then covered by plate B and a second reading is obtained. This reading is a measure of the brightness of the paper. These two readings will give the reflectance.

In the first case, the light incident upon the cell comes from the magnesium oxide disk (in plate A) while in the second it comes from the paper, but in both cases the same area of the paper is exposed. The sphere is thus effected, by the diminished reflectance of the sample, to the same extent in both cases. As a deflection of 20 cm. can be obtained with the standard in position, the method is clearly more sensitive than the usual optical one. The accuracy, however, is another question and depends upon several factors. For very accurate work a different type of cell and sphere would probably be used. The object here is to develop a very simple apparatus utilizing photoelectric methods.

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[1] Hardy and Pineo, *J.O.S.A.*, 21, 502; 1931.

The Weston Illuminometer is also used in the college laboratory to determine, among other things, the distribution of light from various types of lamp shades. The target is mounted upon an arm which rotates about an axis passing through the center of the lamp. Contiguous to this axis is a circular scale, graduated in degrees, for locating the position of the arm. As the galvanometer associated with the illuminometer is provided with three scales, 10, 50, and 250 ft. candle, the intensity in any direction may be readily determined without changing the distance of the target or the use of filters. In a short laboratory period a student is able to determine, with unusual accuracy, the distribution curves for several lamps. It is obvious, of course, that the intensity of any lamp in candle power can readily be determined by this illuminometer or by means of one of the photronic cells and a standard electric lamp, utilizing either the inverse square law or the fact that the galvanometer deflections are proportional to light intensities.

355,000 WILL BE DISABLED IN 1932

Three hundred fifty-five thousand persons in this country will become permanently disabled through accident or disease in 1932, according to a pamphlet just issued by the Federal Board for Vocational Education.

"Reclaimed" is the intriguing title of the publication which is copiously illustrated and which summarizes the national program for restoring physically handicapped men and women to useful employment.

"Once a county charge;" "from laborer to proprietor;" "dependent two years—now a productive worker"—these are some of the descriptive titles to the 18 full-page illustrations in the pamphlet which show vocationally rehabilitated persons on the job as watchmakers, lens grinders, barbers, tailors, linotype operators, window dressers and show card writers, photographers, stenographers, shoe repairers, engineering instructors, and lawyers.

Previously despondent and discouraged, these persons, disabled through infantile paralysis, deafness, loss of arms and legs, tuberculosis, and other handicaps of accident and disease, are examples of the thousands of persons who have been rehabilitated under the national vocational rehabilitation program and fitted for employment in which they are self-supporting and happy.

The problem of the disabled, effects of disabling accidents and disease, prevention and remedy for disablements, the scope of the national rehabilitation program, and the way in which those who so desire may aid in the program, are among the subjects summarized in the new pamphlet of the Federal Board for Vocational Education.

This pamphlet may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C.

THE COLLEGE BIOLOGY CURRICULUM

By Helen Schaefer, *Assistant in Biology Laboratories,*
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In the fall of 1931 the author examined the curricula of two hundred and two colleges to investigate the biology courses offered. The study included the following courses: General Biology, General Zoology, General Botany, General Physiology, General Embryology, General Bacteriology, Comparative Anatomy of Vertebrates, Invertebrate Zoology, Genetics, Eugenics, Genetics and Eugenics, Nature Study, Plant Ecology, Plant Anatomy, Plant Physiology, and Systematic Botany. An effort was made to determine the percentages of schools offering these courses, the year in which they were offered, whether or not they were required, the prerequisites, if any, the amount of laboratory work, if any, accompanying the courses, and the credit given. An attempt was also made to find any general trends in the offering of certain courses by different types of schools.

The statements in this paper are based on the catalogues for the years 1930-1931. Ninety-five teachers colleges, forty normals, thirty-eight state universities, and twenty-eight miscellaneous schools such as religious and privately endowed colleges were investigated. These included ten schools for women and six for men. Forty-seven states and the District of Columbia are included in the study. Florida is the only state not represented.

The catalogue investigation reveals that the following percentages of schools are offering the previously mentioned courses:

GENERAL BIOLOGY
                        Per Cent
Normals 25
Teachers Colleges 53
State Universities 29
Miscellaneous Schools ...49

GENERAL ZOOLOGY
Normals 7.5
Teachers Colleges 48
State Universities 92
Miscellaneous Schools ...69

GENERAL BOTANY
                        Per Cent
Normals 17.5
Teachers Colleges 60
State Universities 94
Miscellaneous Schools ...69

GENERAL PHYSIOLOGY
Normals 4
Teachers Colleges 9
State Universities 26
Miscellaneous Schools ...28

GENERAL BACTERIOLOGY

Per Cent

Normals 7.5
Teachers Colleges 32
State Universities 26
Miscellaneous Schools . . .73

GENERAL EMBRYOLOGY

Normals 4
Teachers Colleges 21
State Universities 78
Miscellaneous Schools . . .81

GENETICS

Normals 7.5
Teachers Colleges 35
State Universities 65
Miscellaneous Schools . . .49

EUGENICS

Normals 0
Teachers Colleges 35
State Universities 13
Miscellaneous Schools . . . 0

GENETICS AND EUGENICS

Normals 7.5
Teachers Colleges 21
State Universities 20
Miscellaneous Schools   .23

NATURE STUDY

Normals 35
Teachers Colleges 67
State Universities 5
Miscellaneous Schools . . .12

INVERTEBRATE ZOOLOGY

Per Cent

Normals 7.5
Teachers Colleges 19
State Universities 47
Miscellaneous Schools . . .39

COMPARATIVE ANATOMY OF VERTEBRATES

Normals 12.5
Teachers Colleges 32
State Universities 73
Miscellaneous Schools . . .84

PLANT ECOLOGY

Normals 5
Teachers Colleges 7.5
State Universities 50
Miscellaneous Schools . . .18

PLANT ANATOMY

Normals 5
Teachers Colleges 4.5
State Universities 63
Miscellaneous Schools . . .29

PLANT PHYSIOLOGY

Normals 10
Teachers Colleges 25
State Universities 94
Miscellaneous Schools . . .60

SYSTEMATIC BOTANY

Normals 4
Teachers Colleges 46
State Universities 80
Miscellaneous Schools . . .60

As the tables show, there are more courses offered in general botany by the different types of schools than any other course. General zoology is offered by the second greatest number of schools and general biology by the third greatest number. It is to be expected that there would be more of these courses offered as they are elementary courses, and, in most cases, are prerequisite for more advanced work. That the curricula are more specialized in the larger institutions is shown by the fact that the smaller schools such as teachers colleges and normals are offering the general biology courses while the

more differentiated courses, botany and zoology, are offered more frequently in the universities. However, although the difference is small, more teachers colleges are offering botany than are offering biology. Of the percentages of schools offering the courses, the universities lead almost invariably. Nature study is in the curriculum of fewer universities and more normals and teachers colleges than any other course. There are no courses in eugenics and only a few in the combined courses, genetics and eugenics, in the normals and miscellaneous schools. General physiology, general embryology, and systematic botany are offered by 4 per cent of the normals, the lowest percenage of courses offered in these schools, and plant anatomy and plant ecology are offered by but 5 per cent. Plant anatomy is offered by fewer teachers colleges than any other subject. General botany and plant physiology tie in popularity among the state universities with general zoology almost equally as popular and general biology far in the background. Aside from nature study, genetics and eugenics and general physiology are the two most unpopular university courses. The catalogues indicate that comparative anatomy is found in the curricula of the miscellaneous schools more frequently than any other course and that nature study is found less frequently than any other course in these schools.

Taking the whole study into consideration, one would find that the greater number of courses give three semester hours credit are electives, and are accompanied by laboratory work. Even the three- or four-hour elementary courses are more popular than the five-hour courses. A number of these courses are six-hour credit courses and run through two consecutive semesters. The results show that junior college subjects and senior college subjects are about equally divided probably because more courses giving senior college credit were investigated while the courses giving junior college credit were offered the greater number of times. In this paper, credit is stated in terms of semester hours.

General bacteriology is a three-hour course in all of the normals, in over one-half of the teachers colleges, and in one-third of the other schools. It is a five-hour course in but 3 per cent of the teachers colleges. In the majority of cases it is a senior college elective with laboratory work. General physiology and general embryology are likewise three-hour, senior

college courses, accompanied by laboratory work in the greater number of schools.

Genetics is commonly a three-hour, senior college course without laboratory work. One interesting fact revealed by the catalogue study is that 35 per cent of the teachers colleges offering genetics offer eugenics also, and the combined courses, genetics and eugenics, are offered in 22 per cent of the teachers colleges, 23 per cent of the miscellaneous schools, and 20 per cent of the state universities. Genetics is offered in the departments of biology or zoology more commonly than in the botany department. Eugenics is a two-hour course in most schools and is not accompanied with laboratory work.

Nature study is a three-hour course in 44 per cent of the teachers colleges and a two-hour course in 33 per cent. In the remainder of these schools the credit may vary from one to five hours. Nearly 50 per cent of the normals offer it as a three-hour course and as a junior college subject. Only about one-half of all the schools investigated definitely mentioned laboratory work.

Invertebrate zoology is almost invariably a junior college subject in the teachers colleges and normals and about equally divided in the state universities and miscellaneous schools.

Over one-half of the teachers colleges offer systematic botany as a three-hour course, while less than one-fourth of them offer it as a two-hour course. Only two teachers colleges did not specify a definite number of hours for the course. In one case, the credit could vary from one to five hours, and in the other there is no mention of credit. Credit for the course in the state universities, however, can in many instances be arranged, the credit varying from two to five hours. The four-credit course is popular with the miscellaneous schools.

Plant physiology, plant anatomy, and plant ecology are likewise quite frequently given as three-hour, elective, laboratory courses offered during the Junior-senior year. Plant physiology is in the curriculum much more frequently than is anatomy or ecology.

The greatest difference in the types of schools is in the number that offer certain courses and not in the courses themselves. The greatest number of courses are offered by the universities, the next by the miscellaneous schools, then the teachers colleges and normals. Another interesting factor obtained from

the investigation is that 46 per cent of the teachers colleges and 38 per cent of the miscellaneous schools require twenty-four semester hours of science for a major while only 7 per cent of the state universities require that number of hours for a major.

The only school that has no biology courses listed in the catalogue is Syracuse University Teachers College in New York. Antioch and Bryn Mawr have no courses in botany but do have a general biology course as well as some zoology courses. Randolph-Macon College offers no botany although work in addition to that listed in the catalogue would be offered on demand according to a statement found in the catalogue.

Throughout the entire investigation of the college biology curriculum, it was found that by far the greater number schools offer more courses, both in variety and number, in the zoology department than in the botany department.

There is little difference in the biology work offered in the schools for men and those for women except that in most cases the schools for women offer more courses. The old idea that botany is a girl's subject cannot be verified by these schools, for one will find that the zoology department is equally as large, if not larger, than the botany department in the colleges for women, and that there is little difference in the botany and zoology departments of the men's schools. Of course, in both cases, some of the schools have much more extensive departments than do others.

Considering all of the miscellaneous schools, one would find but little difference between some of them and the state universities, while others such as Harvard, Yale, Bowdoin, Smith, Roanoke, Randolph-Macon, Princeton, Antioch, and others show a striking difference in that they have a much more limited biology curriculum than do the state universities.

ODOR MAKES SIGHT KEENER

A whiff of the odor of oil of citronella will make you see better, it is indicated by experiments reported to the American Psychological Association by Dr. George W. Hartmann, of Pennsylvania State College. Stimulation of other senses has a similar effect on vision, he found.

"Apparently lights, sounds, smells, pressures and pains do have some property or properties in common for how otherwise would one account for their similar influence on visual acuity?" he said. "The results suggest that one sense might serve in place of another," he concluded.

A COMMON SENSE BASIS OF CHEMISTRY TEACHING IN SECONDARY SCHOOLS

PART I. DEMONSTRATIONS VERSUS INDIVIDUAL LABORATORY

By G. T. FRANKLIN
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Before abandoning a method in educational procedure a close study of its achievements and failures should be made, including a comprehensive criticism of educational methods in general as applied to the particular problem. All factors must be included in estimating the worth of educational practice or else the missing factor may be the dominant one. It has doubtless exasperated many educators to find that what appears to be the most logical method falls down in practice. This means that some unforeseen factor has been overlooked in the estimate. On the other hand too much emphasis should not be placed upon results obtained by traditional methods of examination covering experimentation over a period of months. The application of a method of common sense psychology is likely to be more reliable in the end.

Some common criticisms of educators in connection with general teaching methods include: (1) Too much teacher domination—the continuous development of the teacher in ability of expression at the expense of the pupils; (2) Acquisition for the sake of learning facts—too little application—"cramming processes" overemphasized; (3) Mass production without considering individual differences—freedom of pupil expression too limited; (4) Lack of properly supervised and directed study; and (5) Lack of pupil-teacher contacts.

The individual laboratory method of instruction offers opportunities to meet these criticisms very well. Properly organized and directed (1) it has in it the possibilities of meeting many needs of pupils of varying capacities and inclinations. Without a method of supervised study with proper materials at hand, there is little opportunity to give science training. Teachers generally, after trying many methods covering a period of years, find that they are getting the best results when individual laboratory work is made the basis of the course. The writer was once a student in a class in botany under an instructor of national reputation. The instructor mentioned in

his first lectures that he could not make much progress until the class had done more laboratory work. After the class had done numerous exercises in laboratory work, the gifted teacher proceeded to use the facts thus obtained to illustrate principles. Charts, lantern slides, etc., then had meaning. Lecture-demonstrations have their best meaning and carry with them lasting benefits when they are done in close correlation with individual laboratory work. (2) When the beginner sees work done by the instructor, he senses the idea best when it includes his own experience. By watching the work done with better technique the pupil learns how to improve his own efforts. He is more interested because the work is more closely related to his own problem than if he had never attempted to do an experiment. Lecture-demonstrations have a very important place in a beginning course in chemistry (3) but they are no substitute for individual laboratory work. The two methods, properly balanced, should constitute the basis for a sound course in chemistry. There is grave doubt as to the cultural value of a course based upon any other foundation. Based upon proper foundation, the cultural value of a science course has great possibilities. The appreciation of modern activities in the creation of basic industries, the assimilation of facts of modern progress, are best achieved when pupils go through motions imitative of the methods by which it has been and is being done. This is especially true of the less gifted in imagination who are less able to enter sympathetically into an understanding of people's activities without having had some experience in the activities.

The apparent loss of time and wasted effort in beginning laboratory classes should give no great concern. Accidentally the writer has had the experience of teaching a small class with materials handy and thus the least possible waste of time was made possible. It was observed that the pupils went through their work so hurriedly that there was not the proper time to fix the facts in mind and associate them. Because a pupil has to wait a reasonable time for materials to proceed from one part of the problem to the next is no loss and may be a gain. Just what the pupil thinks about while detained momentarily to obtain materials depends upon his interest in the work, but unconsciously or otherwise he cannot refrain from continuing the mental process of thinking over the work completed

so far. If many errors are made in the work, necessitating repetition, it is not altogether bad (4). The fact is apparent that when all pupils go through the work without a mistake, the work is too easy and full value of the laboratory exercises is missing. Many teachers find it better not to do all of an exercise in one day. It is doubtless better in many cases to do positive reactions one day followed by negative ones and an "unknown" on another day. Instead of curtailing individual laboratory work, more research should be made to unlock its latent possibilities.

It is customary for writers to state objectives (5). It is all very well and good, but to define for all time and all places an objective that fits all circumstances is quite impossible. The objective is about as illusive as the *summum bonum* of the philosophers, some of whom sought the highest good in pleasure (Hedonism), while others sought it in human service. Some have expressed the idea that governments, human institutions in general, may be a "sort of convenient scaffolding" in our climb to better civilization, a scaffolding that "should be removed as we advance." The idea doubtless has an element of truth in it and every teacher should keep an open mind to possible changes for betterment, only it should be definitely shown that the change is for the better before making it.

It is quite obvious that specific objectives are more or less temporary and vary with time and locality. Some reasons for studying chemistry with the idea that they are not complete and that some of them are general reasons for the existence of schools are given. They are: (1) The acquisition of helpful foundation work in such vocations as medicine, pharmacy, agriculture, mining, etc.; (2) The acquisition of knowledge that may be useful in a general way in law, journalism, detective work, etc.; (3) The cultivation of habits in the scientific method; and (4) Activity for the sake of activity in doing interesting work, the protection of youth from idle drifting, preparation for leisure, avocation, better citizenship.

It is quite apparent that individual laboratory work is very important in the achievement of such objectives. It is not uncommon to find in the supply houses fathers and sons purchasing equipment for the home laboratory. Administrators insist that teachers shall "make the work interesting" so that the pupils will attend school better. It is the experience of teachers

that when laboratory work days are due the attendance is invariably better. It is the heart of the course from the standpoint of importance and interest to the pupils.

A careful statistical study is not needed to show that very few of the students of elementary chemistry will ever use it as a direct means of livelihood. However, it will take something more than figures and arguments of professors of schools of education, business men and others with little to recommend their complete understanding of the situation, to convince the public that its boys and girls are not entitled to compete for the grand prize of professional achievement. It matters not what the goal is that may be set up by the professional educator, the dreams of fond parents are not to be mocked.

Invention creates leisure; the research laboratory creates new things to make leisure more desirable. Through these the race makes progress. To say that the race has reached the end of progress is unwarranted pessimism. If such were the case, the secondary school might as well be abolished in large measure. To go backward is easy and does not require an expensive school system to achieve the purpose. The school system is generally behind, it is true, but working to bring the public up to the achievements of the gifted few, who have gone ahead. To go forward is courageous and represents the hope of the race. The public school will not survive a restriction on opportunity; it is of necessity a democratic system, deriving its support from the masses. It rises or falls in proportion as it is made to operate with this idea in mind.

The Chicago Chemistry Teachers' Association recently conducted a poll among the pupils in the various chemistry classes in Chicago. The pupils were asked on secret ballot to indicate their choice of lecture-demonstrations or individual laboratory work. The number of pupils voting was over four thousand. The number favoring the retention of the laboratories was preponderantly large—over 93 per cent. Forty-eight teachers expressed themselves definitely in favor of retaining the laboratories. The records are interesting. Of the pupils, who voted in favor of teacher-demonstration, it was observed that they belonged in large part in the classes of experienced teachers, teachers long practiced in the art of doing experiments and lecturing at the same time. It is the general opinion of the teachers that if lecture-demonstrations are to take the place of

individual laboratory work, specially trained teachers will be needed for the purpose. The laboratories would have to be remodeled to meet the needs of this type of teaching, entailing much expense. However, if it could be shown that such a change would be for the betterment of chemistry teaching, the teacher to be consistent with his science training, would sanction the change. No proof of a better substitute for individual laboratory work has ever been offered. The strict methods of science cannot be successfully applied to the measurement of school activities. The ordinary methods of testing would doubtless indicate better results in a school devoid of athletics and student clubs as compared with a school as we know it, especially if the study continued no longer than one semester, yet most of us would hesitate to eliminate these activities from the school system. Any improvement in scholastic results would likely be temporary. The factors by which social institutions grow are not readily measured; they are as changeable and temperamental as the individuals composing them. The leaders merely grope along, intuitively feeling their way through, without the comforting devices of compass, sextant, etc., of the traveler or engineer. The factors with which they deal are devoid of constant values and they are too numerous, even if they did have constant values in certain conditions, to be evaluated in terms of one another and placed in mathematical equations. In the same way the teacher as the leader of young people works her way through the months of the school year, feeling the need for varying the methods here and there to fit the class and the conditions, ever changing, under which they work, conscious of the fact that the best in human achievement if often accompanied by spells of forgetfulness of the main purpose. There is a feeling, that, while the laboratory should not be made the place for play and entertainment any more than the recitation room be made a place for continuous clowning, yet a need for enlivening the work is many times present (6). Common sense is the guide in determining the extent of quantitative experiments and drills on fundamentals. The experienced teacher knows that only a few of the human race are capable of applying themselves continuously to the attainment of a goal unaccompanied by "side-reactions." The most serious aspects of life are often eclipsed by the lighter social activities—parties, dances, dinners, etc.

The few hold in mind constantly the purpose—the gifted few. If schools existed for the few alone, the logical course prepared by intelligence would be the natural course and the teacher would not be worried by the need for variety of method and a resort to lighter and less intelligent procedures, in order to maintain interest and class morale.

A second paper to follow will contain some suggestions for the improvement of individual laboratory work.

SOME READING SUGGESTIONS

1. Ralph E. Horton, "Improvement of Scientific Ability through the Use of the Individual Laboratory Exercises in Chemistry," *Journal of Chemical Education*, 6, pp. 1130-1135, June, 1929; Bradt and Gerwe, "More Effective Individual Laboratory Instruction in General Inorganic Chemistry," *ibid*, 8, pp. 1574-1580, August, 1931; Ira C. Davis, "A Contract in Chemistry; Calcium and Its Compounds," SCHOOL SCIENCE AND MATHEMATICS, 31, pp. 292-296, March, 1931.

2. A. W. Davison, "Lectures and Lecture Experiments," *Journal of Chemical Education*, 7, 1305-1309, June, 1930; Richmond T. Bell, "The Scientific Method in Practice," *ibid*, 8, pp. 1817-1823, September, 1931; Don Van Horne, "The Lecture-Demonstration Method in High-School Chemistry," *ibid*, 7, pp. 109-116, January, 1930; L. A. Wiles, "The Value of the Lecture-Table Demonstration in the Teaching of Chemistry," *ibid*, 5, pp. 1109-1111, September, 1928.

3. Arthur B. Gould, "Demonstration Experiments and Their Place in the Teaching of Chemistry," *Journal of Chemical Education*, 8, pp. 297-302, February, 1931.

4. G. Albert Hill, "The Freshman Course with Particular Reference to the Laboratory Work," *ibid*, 6, 914-917, May, 1929.

5. Kimber M. Persing, "Present Specific Objectives in High-School Chemistry, *ibid*, 6, 1958-1978, November, 1929.

6. R. C. Bergen, "Chemistry on the High School Stage," *ibid*, 6, pp. 963-965, May, 1929; John J. Condon, "A Chemistry Club Banquet," SCHOOL SCIENCE AND MATHEMATICS, 31, pp. 989-991, November, 1931.

CHEMICAL TREATMENT OF INSANITY REPORTED

Fifteen insane patients were reported improved and two of these apparently cured through the use of sodium amytal, Dr. Harry R. DeSilva of the University of Kansas reported to the American Psychological Association. The study was made in an effort to test the theory proposed by Dr. Wilder D. Bancroft, chemist of Cornell University, that insanity is due to the state of the colloids of the brain. Sodium thyocyanate did not produce the results predicted by Dr. Bancroft. In commenting on the paper, Dr. Erich Lindemann, of the University of Iowa, said that other substances having a similar chemical effect on the brain colloids do not have the same therapeutic effect as sodium amytal.

DIFFERENTIATED ASSIGNMENTS

By Mabel Sykes, *Bowen High School, Chicago, Illinois*

The possibility of providing for individual differences in mathematics classes is attracting widespread attention at the present time. The various attempts to solve the problem might be classified under such heads as individual instruction, ability grouping, and differentiated assignments. Individual instruction includes such variations as The Winnetka Plan, The Dalton Plan, which is used throughout the South Philadelphia High School for Girls,* and lesson sheet classes for pupils that for any reason are behind in their work or do not seem to be fitted for the work as given in the regular classes.

Of the various plans in use ability grouping seems to be the most popular while the possibilities of differentiated assignments do not appear to have received the attention that the subject deserves.

As here discussed differentiated assignments include all cases in which the assignment for pupils in one and the same class is made to fit different levels of ability. It goes by various names such as differentiated assignments, flexible assignments, contract work, and the like.

The idea underlying both ability grouping and differentiated assignments is really the same: namely, that it is not necessary or even desirable that all pupils do exactly the same work. All pupils need not do or even try all the harder exercises and problems in algebra, or prove all the theorems, or do exactly the same originals, or the same number of originals in geometry. Indeed slower and weaker pupils often get a better grasp of the subject as a whole if they omit some of the more difficult work.

Where ability grouping is most successfully employed the work for the slower classes is cut down and carefully adapted to the needs of the class and the class gets more explanations and more detailed explanations than classes composed of the brighter pupils. It is necessary however that such classes be in the hands of a teacher especially sympathetic and resourceful, one who is well adapted to and enjoys such work. Without such a teacher there is little or no inspiration when the brighter pupils are withdrawn. The pupils do not profit by the work as

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* See *Educating for Responsibility*, by Dr. Lucy L. W. Wilson; Macmillan, 1926.

was hoped and the teacher finds it more or less of a drag.

If, however, assignments given to pupils in the same class are made to fit different levels of ability, certain disadvantages connected with ability grouping disappear and most of its advantages are retained. There are practically no administrative difficulties involved. The presence of the brighter pupils tends to keep up the interest and inspiration. The slower pupils profit by contact with the brighter ones; they get some idea of how the better pupils work and get a broader view of the subject by hearing the reports on the harder exercises and theorems, even if they are not required to reproduce all of these. The brighter pupils do just as much independent thinking as in ability grouping.

Of course, in such work as in ability grouping the teacher must be in sympathy with the plan and with the difficulties of the weak pupils and must be resourceful in planning assignments. It is possible, however, for the teacher to feel her way little by little varying the assignments more or less from time to time and from class to class until she has worked out a scheme adapted to herself and her pupils. All teachers are not alike any more than are all pupils.

Illustrations of such work came under the writer's notice while visiting schools during sabbatical leave. A few are given.

CASE 1. A GEOMETRY CLASS

The assignment is like a weekly contract and is given at the beginning of each week. A minimum is always carefully designated. At least one oral report a week is required of each pupil and must be on something covered by the assignment. One day a week the teacher does most of the talking giving sometimes a preview, sometimes an organized review. One written test is given each week which may, or may not, take the entire period. Written work on the assignment is accepted. It is sometimes done in class and sometimes not. The writer visited the class on a day when many oral reports were given but fully appreciated the fact that it might often be desirable to devote the entire lesson to something like laboratory work. The text used is Strader and Rhoads.

CASE 2. A GEOMETRY CLASS

At the beginning of the geometry the teacher devotes a few weeks to general class discussion. In making the assignments

for contracts the subject covered by the assignment is definitely given. The assignments are short, not covering more than two or three days. Three assignments are made: *A, B,* and *C* contracts. The *C* contract covers more than the minimum essentials. This teacher says that she has been "playing with contracts" for five or six years but still feels that it is in the experimental stage. She adds, "It is astonishing how much more enthusiastic the pupils become when working on contracts. In doing originals in geometry a teacher is apt to be literally swamped and is placed in the embarrassing position of either having to kill herself or to dampen their ardor." The writer visited one of her second semester geometry classes. The pupils were working at their seats from a mimeographed page of originals on equal areas. The visitor was a little startled at first to hear the class told that when they needed help they might bring their work either "to me or to Miss Sykes." A most interesting period was the result.

The following is a sample assignment given by this same teacher:

Text; Wells and Hart, pages 208 and 209. *Time;* 2 days.

The Unit; The area of a parallelogram equals the product of the base and altitude.

C Contract; Write the proposition and the corollaries, Exercises 23, 24, 25 and 26.

B Contract; All of *C* contract and exercises 27, 28 and 29.

A Contract; Write the proposition. Recite the corollaries. Exercises 25, 26, 29, 30 and 31.

The corollaries referred to are:

I. Parallelograms having equal bases and equal altitudes are equal.

II. Two parallelograms are to each other as the product of their bases and their altitudes.

III. Parallelograms having equal altitudes are to each other as their bases.

IV. Parallelograms having equal bases are to each other as their altitudes.

The following are samples of the exercises in the three contracts:

C 1. What is the area of a rectangle with altitude 15 ft. and base 20 ft.?

2. What is the altitude of a parallelogram whose area is 56 sq. in. if its base is 14 in.?

3. Construct a parallelogram equal to twice a given parallelogram.

4. Construct a rectangle to two-thirds a given parallelogram.

B 1. Divide a parallelogram into four equal parallelograms by lines parallel to one side.

2. Construct parallelogram *ABCD* having *AB* equal 3 in. and *BC* equal 4 in. and having angle *B* equal to 30 degrees; determine the area of the parallelogram.

A 1. On line *AB*, place *C* and *D* so that *CD*= 2 in. At *C*, construct *CF*⊥ to *AB*, making *CF*=1 in. Through *F* construct *XY* perpendicular to *CF*. At *D* construct *DE* perpendicular to *AB*, meeting *XY* at *E*. What is the area of *CDEF?* Various parallelograms are drawn on *CD* as a base and between the parallels *AB* and *XY*. Their areas are determined and a general conclusion is drawn.

In writing of her work this teacher adds the following note for the benefit of her correspondent: "Students working on the *A* contract do not need the practice on the simpler exercises. Also they must be given enough hard work to keep them suitably humble."

CASE 3. A GEOMETRY CLASS

The following contracts on "Angles Measured by Arcs" were obtained from a teacher enthusiastic and successful in such work. In this case the contracts are used in connection with the unit or topic method.

I. *Aim.*—Understanding of formal proof and application of theorems dealing with the measurement of angles by their intercepted arcs.

II. *Texts.*—Clark-Otis (1927 copyright, third printing.) and Palmer-Taylor-Farnum.

III. *Plan.*—Theorems and corollaries of *D* contract are to be given orally as individual demonstrations. Exercises of *D* contract are to be written in best form on theme paper and to be handed in September 29th at 8:15. All other contracts are to be worked on theme paper and handed in at 8:15 on September 29th.

IV. *D* Contract; (Clark-Otis)

1. Paragraphs 239 (three cases), 240, 242, 243, 244 and 246.
2. Exercises Page 156; 1, 2, 5: p. 158; 1: p. 159; 15: p. 160; 2, 3: p. 162; 2: p. 163, 8, 9, 10.

C Contract; (Clark-Otis)
Page 156, Ex. 3; p. 158, 5, 9; p. 159, 12; p. 160, 4; p. 177, 19, 20, 22, 28.

B Contract; (Clark-Otis)
Pages 304 and 305, Test IV.

A Contract; (Palmer-Taylor-Farnum)
Page 166, Ex. 6; p. 169, 7; p. 173, 11; p. 174, 17.

The theorems of the *D* contract must be demonstrated individually by each member of the class, with no exceptions, and are tested in the test on the entire unit. To complete the *A*

contract a pupil must already have completed the *D, C,* and *B* contracts; the *A* work is added work and not a complete contract in itself. Similarly if a pupil wishes to undertake a *C* contract, he must first complete the *D* contract and then proceed to prove his *C* ability. If he wishes a *B* standing he must first complete the *D* and *C* contracts. Contracts *C, B,* and *A* are not accepted unless accompanied by those that precede.

The theorems and corollaries referred to in the *D* contract are the following:

I. The theorem concerning the measure of an inscribed angle.
      Cor. 1. An angle inscribed in a semicircle is a right angle.
      Cor. 3. Angles inscribed in the same arc or in equal arcs of a circle are equal.

II. Theorems concerning the measure of an angle formed by: (a) a tangent and a chord; (b) two chords intersecting within a circle; (c) two secants, a secant and a tangent, or two tangents drawn to a circle from an external point.

The following are samples of the exercises required under the various contracts:

D 1. Is an angle inscribed in an arc that is less than a semicircle acute or obtuse? Prove your answer.
    2. Two equal chords *AB* and *CB* form an inscribed angle of 65 degrees. How many degrees are there in arc *AC?* Arc *AB?* Arc *CB?*
    3. *PX* and *PY* are tangents to circle *O* at *A* and *B* respectively. Find *P* when major arc *AB* equals 250 degrees.
    4. In $\triangle$ *ABC, AC* = *CB. ABC* is inscribed in a circle. *XY* is tangent to the circle at *C* and arc *AB* equals 88 degrees. Find the number of degrees in angle *XCA.*

C 1. Is a trapezoid that is inscribed in a circle isosceles?
    2. If the opposite ends of two parallel chords are joined are the triangles so formed isosceles?
    3. If arc *AT* contains 100 degrees, then angle *PTA* formed by chord *AT* and tangent *PT* contains ——— degrees.

B 1. The *B* contract is a modern type test consisting of twenty-eight questions involving measurement of angles and related topics.

A   The exercises in the *A* contract are harder and involve more formal proofs.

IN GENERAL

Certain points in connection with such work may be noted:

1. Differentiated assignments may be used with or without the unit or topic method.

2. The contracts may cover any length of time from two or

three days to two or three weeks. One case was reported to the writer in which the topic method was used but the contracts instead of covering the entire topic, as in Case 3 above, covered only two or three days, that is, many contracts were assigned before the topic was completed and a test could be given.

3. The easier exercises need not be required of the better pupils. (See Case 2.)

4. In Case 3 it looks as if all pupils were obliged to prove all theorems. There are many topics, however, in which the harder demonstrations might well be omitted from D and C contracts. The reference under the B contract in Case 3 is to a modern type test which contains questions on theorems not required in any of the contracts. It is evident, therefore, that an acquaintance with the facts stated in these theorems rather than with the demonstration of the theorems is all that is required and that of B and A pupils only.

5. In Case 1 volunteer reports on theorems and exercises were not only accepted but encouraged. Suggestions are given below for conducting work in this way.

As the class assembles pupils who wish to report on some definite piece of work leave their names together with the number of the theorem, or the reference to the exercise on the teacher's desk and proceed at once to put the figures on the board. Such work must be carefully supervised. It is often necessary to hold back some aggressive pupil who has a tendency to monopolize the time. Weak pupils have to be encouraged and lazy ones spurred on. To this end it is often necessary to suggest in advance to some pupils on what to report. Here is where differentiated assignments come in. Reports on the easier exercises are of value and can be made by the weaker pupils.

It is often desirable that reports be given several times on the same theorem or exercise. As it is not possible, however, to allow time for each pupil to report orally on everything in his contract, written work must also be accepted. This may be prepared in or out of class. But some oral reports should be expected of every pupil and the work should be so managed that everything in each contract is given orally at least once and many things several times.

When the work is conducted in this way pupils learn more. The weaker pupils get a better idea of the topic as a whole

and everyone gets more fun out of it than when the work is conducted by the older methods. If a pupil can decide for himself in advance on what he is to report he is more likely to do a good piece of work than if he considers himself liable for anything in a given daily assignment. He is encouraged by the fact that he has given a correct demonstration and timid pupils get accustomed to giving demonstrations before the class. The class may be questioned on the details of each report as it is given so that the attention of the entire class is secured. Weak pupils learn from reports given by the better pupils even if they are not required to reproduce everything and the better pupils have a chance to work on problems worthy of their ability.

ALGEBRA

It is perfectly evident that intermediate, or third semester, algebra work can be conducted in this way. The writer has, however, no details of such contracts to report. The following variation of the plan may be of interest:

When a new topic is to be studied it is first developed and discussed with the class as a whole, after which one or more short tests are given to the entire class. From the results of these tests the class is divided into three groups, *A, B,* and *C,* and further drill material consists of graded exercises adapted as far as possible to these three groups. This drill material for any one day is short, giving time for discussions and questions. Thus the entire class hears all the material discussed. Weaker pupils are apt to be confused when working on the longer and harder exercises and this confusion of mind is liable to result in more bad algebra than when their work is confined to easier things. The personnel of the *A, B,* and *C* groups varies from topic to topic, and even from day to day on the same topic. Volunteer reports on differentiated assignments might also be used to advantage at this stage.

The writer saw no work of this kind in ninth grade algebra and has had no ninth grade class herself for some time. Possibly some one interested in this work as adapted to such classes would be willing to report on it.

An article appeared in the October, 1930, issue of the *Mathematics Teacher* entitled "Experimental Work and Special Classes in Mathematics in the High Schools of New York City," which describes such work there.

A LABORATORY APPARATUS FOR THE DETER-
MINATION OF THE ACCELERATION OF
A FREELY FALLING BODY

By R. M. Bowie, *Iowa State College, Ames, Iowa*

A subject of interest to pedagogical physicists is the demonstration of the acceleration of freely falling bodies to elementary students. It is true that the properties of uniform acceleration can be studied or the value of g can be determined very accurately with very inexpensive apparatus, but a direct method of showing the acceleration of freely falling bodies is a more difficult task. Such instruments have been designed and are on the market. However, most of these are more or less expensive and are, therefore, not available to many. In our elementary laboratory, an inexpensive one has been developed.

The instrument described here consists essentially of an electromagnet which is energized, when a key is pressed, by alternating current from the 60 cycle, 110-volt line. The one-inch steel ball is suspended from this electro-magnet and is released upon opening the key. The opening of the key allows the current to pass through the timing device until the ball in its fall strikes and opens a switch. This terminates the time record. The timing device may consist of potassium iodide soaked paper over which two styluses are run by hand. The 60-cycle current makes these alternately negative and positive, then positive and negative. It has been found that, when the current is flowing from a stylus, iodine is deposited on the paper, probably in the form of KI_3. When the current is in the opposite direction, no deposit is formed. Evidently, then, 120 spots per second will be formed while the current is flowing. The number of spots made during the time of fall is, therefore, a measure of this time.

We may now look at the circuit used (Figure 1). The 440 W heating coils is used merely to limit the current to a value of about five amperes. When the key is closed, the current passes through the primary of the Ford coil, thus energizing it. As the stylus circuit is shorted, no current flows between the styluses and no spots are produced. Upon releasing the key, the ball falls and an alternating potential difference is set up between the styluses, causing spots to be formed at the rate of 120

per second until the magnetic switch is knocked open by the falling ball. This evidently stops the stylus current.


Wiring Diagram for Free Fall Apparatus
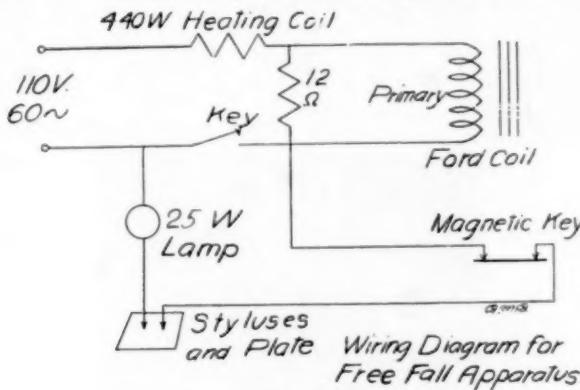
Fig. 1

Before describing the exact procedure, it will be necessary to describe the apparatus. It is evident from the diagram, that most of the parts are inexpensive and quite common. The 440-watt heating coil is the element from a reflection type electric heater and fits into an ordinary lamp socket. In order to use the Ford spark coil, it is necessary to remove the vibrator assembly by removing the five nuts from the top of the coil. If the coil is placed in the position it would occupy in the car, contact is made to the right hand one of the tall screws on top. The other connection is made by soldering to the contact at the bottom of the coil. The key can be any tapping key that will pass five amperes. A knife switch will do if necessary.

The ball used is of steel and is one inch in diameter. The air resistance produces a noticeable effect upon balls of smaller diameter. The magnetic switch, whose position below the electromagnet is variable, is made of a magnet from a model T Ford. The poles are first wrapped with several layers of black friction tape. The bare ends of wires are then wound about this six or eight times. There is, thus, no electrical connection through the magnet from the wire around one pole to the wire about the other. A strip of sheet iron half an inch wide and about three inches long when placed across the poles will be held in position by magnetic attraction and will make the connection between the two wires about the poles.

In FIGURE 2, the coil and the magnetic switch can be seen in position. The galvanized iron strip can be seen below the mag-

net poles. The manner of support used is incidental. It is important only that the coil be suspended upside down and that the magnet, in a horizontal position, be so arranged that it can be raised and lowered. In FIGURE 2, a large ring stand six feet tall is shown. The coil is supported by a table clamp and the magnet by a large universal clamp.
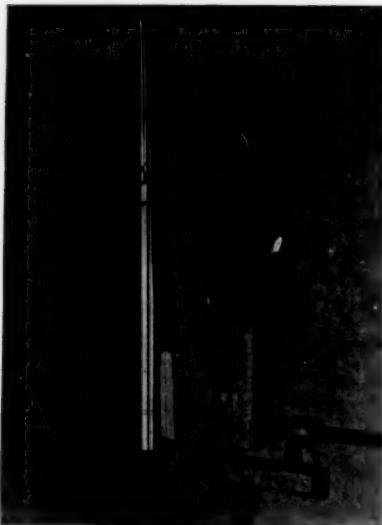

FIG. 2

Both styluses are fastened to the end of the same stick so that they can be run across the paper simultaneously. The stick has dimensions of about ½" x ½" x 12". Two holes are drilled through it about half an inch apart and near one end. Bolts are put through the holes and the wires fastened to one end of each. Under the other end of each, is fastened a short piece of 56 wire gauge size spring iron wire about an inch and a half long. The end of each is bent sharply so as to make a smooth but small contact to rub on the paper. The exact size and shape of the styluses is not important. Small copper wire will work if it is stiff enough. The paper works best if placed upon a sheet of metal such as galvanized iron.

The twelve-ohm resistance in parallel with the primary consists of a slide resistance rated at 25 ohms, 5 amperes. It has been found that a 21-21 candle power, 6-8 volt head light bulb will work almost as well if both filaments are connected in parallel. Although the circuit will work without this resistance,

it is advisable to use it. The reason is that the inductance in the primary causes the current to lag behind the voltage while the key is closed. On opening the key, the lag is diminished almost to nothing so that one frequently obtains an extra spot on the record. A resistance in parallel reduces the phase angle to the point where it does not bother the results.

The following write-up with a few alterations was used in our laboratory:

UNIFORMLY ACCELERATED MOTION

Purpose.—To determine the acceleration of a freely falling body and to show its uniformity.

Apparatus.—Free fall apparatus.

Theory.—Every body on this earth is acted upon by the force of gravity. When allowed to fall, this force imparts to the mass an acceleration which is uniform and which may be determined by this equation: $d = \frac{1}{2} at^2$, where d is the distance of fall, a is the acceleration, and t is the time of fall. The first of these three quantities is easily measured, while the last is more difficult to obtain.

On this apparatus, the distance is measured from the bottom of the ball as it is suspended from the electromagnet at the top of the apparatus to the bar on the magnetic switch which the ball opens when it falls. In measuring the time of fall, use is made of the fact that the 60 cycle alternating current, so commonly used for lighting, changes direction 120 times a second. (An idea of the accuracy of this number can be obtained from the fact that electrical clocks depend upon this for their time.) When the key is opened which lets the ball fall, it also makes connection to the two styluses which are drawn slowly across the recording paper. One stylus makes a spot when the current goes in one direction while the other makes one when the current reverses. Together, they make 120 spots a second while the current is turned on. When the ball hits the bar on the magnetic switch, it opens the circuit and the current to the styluses is shut off.

Thus, the styluses only mark from the time the key is opened until the ball opens the magnetic switch. The total number of spots minus one, divided by 120 is the time of fall in seconds. The first spot is a zero spot as it is made just as the ball starts to fall. For this reason, one is subtracted from the total number. Substitution in the above formula will give the acceleration.

Procedure.—1. Preparation of the recording paper. Place a sheet of mimeograph paper on the metal plate and dampen it thoroughly with recording solution. After it has become dampened throughout, squeeze out the excess solution by means of a photographic squeegee roll. (If such a roll is not available, stand the metal sheet on end and allow the paper to dry until it is just moist, not wet.)

2. Adjustment of apparatus. Place the bar on the magnetic switch and adjust its position to the desired level. Press the key and suspend the ball from the electromagnet. To make sure the apparatus is in align-

ment, open the key and see if the ball knocks the bar off of the magnetic switch.

3. Making measurements. Place the ball on the electromagnet and the bar on the magnetic switch. While drawing the styluses slowly across the recording paper open the key. Count the spots in both rows and record the number.

4. Number of measurements required. (This may be varied.) Make measurements at the bottom of the ring stand and at 10 cm. intervals above until you have taken 10 sets. Make three readings at each level. Calculate your results.

There are two solutions which may be used for recording; they are as follows:

1. Potassium Iodide	20 gms.
Water	80 cc.
2. Common salt, NaCL	15 gms.
Potassium ferricyanide	5
(Red prussiate of potash)	
Water	60 cc.

Solution No. 1 will keep indefinitely. However, the brown spots formed will disappear in about two minutes so that they have to be counted at once. This solution is also about twenty times as expensive as No. 2. Solution No. 2 does not keep as well. It should be made up fresh every day or so. The spots in this case are blue on a yellowish background. After the record has been made, the excess solution can be washed out in running water, leaving permanent blue spots on white paper.

This apparatus is certainly not as complicated and is probably as accurate as any we have used. In the hands of the students, it gives values of g agreeing within 2 per cent with the accepted value.

The author is deeply indebted to Dr. P. H. Carr, who is in part responsible for the development of this apparatus and who instigated the work upon it. He is also indebted to the Physics Department for the parts used in making this instrument.

VIBRATING TUBE HELPS CONCRETE TO FLOW INTO PLACE

A novel method of tamping concrete placed in forms of walls and other structural units is coming into use. It is a tube within which an eccentric weight is revolved in such manner as to cause it to vibrate 5,000 times per minute. This tube is inserted into the plastic concrete being placed and the vibration aids it to flow around reinforcing rods and into the narrow parts of the form-work. It is claimed that one such electric tamper will do the work of five to fifteen hand tampers.

RECENT EDUCATIONAL RESEARCH IN SCIENCE TEACHING[1]

By Morris Meister
New York Teacher Training College, New York City

In the year 1999 a teacher appeared before a Board of Examiners to take a qualifying examination for a license to teach science. Having satisfied the requirements as to training, experience and record, and having demonstrated in a written paper his knowledge and understanding of the subject matter of science, there now remained a final question in the minds of the Examiners. "Does this candidate possess a satisfactory philosophy of science education and has he kept in touch with certain professional aspects of his work?"

Let us assume that this Board is everything that such a Board should be and also that our teacher will be eminently successful. Can we dare to project into the future and predict both the questions and the answers? If only for the sake of raising discussion, the speaker accepts this challenge. Even if his effort be futile, it may, nevertheless, succeed in drawing a sharp picture of recent educational research in science teaching, which is, after all, the subject of this paper.

"First of all," asks the Examiner, "Can you please tell us what you consider to be the objectives of science teaching in relation to the aim of education?"

And the prospective teacher replies:

"Effective participation in a democratic social order is the goal of education which has seemed acceptable ever since the World War. The growth of science and its contributions to life have been so great, that an individual's understanding of and participation in our existing social system are seriously impaired if he does not possess a thorough appreciation of the important generalizations of science. The latter have come to function in at least three distinct ways. They constitute a body of knowledge which must be experienced and mastered, they represent a method of thinking which civilization has had to adopt for its own self-preservation and they indicate a set of habits and attitudes which insures future progress.

"Objectives in science teaching have had a long and interest-

ing history. As far back as 1875, in an age when formal discipline was popular, science was taught for its informational value alone. After 1875, the colleges assumed control over objectives, standardizing our textbooks, teachers and methods to the one purpose of preparing for college. It was in 1900, however, that a concerted effort began to revise our objectives in the light of economic changes and of developments in educational philosophy and psychology. When standards of living were raised, when the need of industry became important, when millions rather than thousands flocked to our high schools, mere preparation for college had to be discarded as an objective. Simultaneously with this change in point of view came a new philosophy of education and the beginnings of real knowledge of the laws of learning, the transfer of training and of individual differences.

"As a result, there followed in quick succession several points of view with respect to objectives in science teaching. First, came a period in which science taught the practical applications of everyday life. This gave way to science for its civic or citizenship value and later, to science for its vocational value. Between the years 1920 to 1930, the dominant objective for science teachers was to teach their subjects so as to interpret the environment of the pupil. But serious difficulties in determining exactly what is the pupil's science environment for teaching purposes, caused thinkers in science education to look elsewhere for guidance.

"In the year 1932, the *Yearbook of the National Society for the Study of Education*, formulated an important set of objectives for science teaching. The work of Downing and his students and the work of Powers and his students have set up these objectives at all levels in the form of large generalizations or principles which have influenced thinking and living in our existing civilization. Since 1932, the task of science teachers has been to develop an effective program of pupil experiences that could be organized and associated into the big concepts of science, revising our objectives as the science concepts themselves changed and grew. Thus in the year 1950, the distinct subjects, Nature Study, Elementary Science, General Science, Biology, Physics, Chemistry, etc., ceased to have their former significance as separate fields of study; although actual practice has indicated that certain generalizations may be begun in

the kindergarten, while others had best be delayed until the 5th grade, 10th grade and so on.

"One problem which was left unsolved and with which investigators today are still struggling, is the development through science study of what might be called the Scientific Habit of Mind. It is very clear that knowledge alone is insufficient for effective participation in our social order and that even skill in using the method of scientific thinking does not always promote social welfare. It is not clear, however, that classroom experiences in science can emotionalize pupil attitudes toward science and scientific work. When will men and women habitually permit facts to take precedence over beliefs, cease to argue for the sake of victory, avoid secrecy and patents, seek full criticism of their achievements, never regard knowledge as final or truth as absolute? Such habits of mind should be the result of science study; but they do not seem to be, at least not to any considerable extent.

"One of the pioneers in this field of inquiry was Whitsit, who developed a tentative approach to the problem in 1928, in connection with a syllabus in Physical Science for the high schools of New York State. His point of view was embodied in an extended and inspirational report by Superintendent Tildsley entitled, *Teaching Science as a Way of Life*. This report is based on answers to a questionnaire made by 16,000 pupils of New York high schools; and while no attempt is made to draw conclusions that are statistically valid, evidence is presented to indicate that pupils are coming to view science as a 'force in the making over of their lives; that under the leadership of teachers who know the "way," these boys and girls vision a richer and larger world in which they too may walk, larger.'

"The conception of science teaching presented by this report is, for 1928, revolutionary, in that it calls for the abandonment of subject matter as a satisfying objective of science teaching and makes this objective subordinate to the development of qualities, habits and attitudes which ultimately, the teachers believe, will bring about a new and better social order."

"Now," asks the Examiner, "tell us if you will, about the sequence of science study from Grades I to XII."

And our candidate, who by this time should have completely satisfied the inquisitors as to his qualifications, makes reply:

"The question of sequence in the science curriculum came

prominently before teachers of science in about the year 1925. Before that time there was considerable wrangling among the advocates of this or that specialty. One of the most interesting episodes was the rapid rise of General Science which found a place for itself in Grades VII, VIII, and IX. The growth of this subject was largely instrumental in focusing attention on the matter of sequence. By 1930, the subject matter of General Science was sufficiently well crystallized to make necessary certain adjustments in both that which preceded General Science and in that which followed it. Thus, the subject called Nature Study, which flourished up to 1925 began to give way to a type of work called Elementary Science. By 1940 the replacement was complete. Advocates of Biology, Chemistry and Physics as special subjects gave up their unproductive struggle for supremacy among the subject matters to be included in General Science. Instead, the years 1925-1930 saw an intensive attack upon the problem of reorganizing the courses in Biology, Chemistry, and Physics so that they too might carry on from where General Science leaves off and so that they might themselves harmonize with each other in promoting the aims of education. The work of Leker in 1925 and of H. A. Carpenter in 1930 are important in this connection.

"As a result of investigations by Caldwell, Curtis, Persing, Harap and others, individual opinion as to importance of items of content was replaced by a set of criteria objectively arrived at and statistically applied. Studies of the science interests of children such as those by Finley, Pollock, Curtis, Meister and Palmer and analysis of textbooks and courses of study, such as those by Webb, Downing, Hillman and others gave some degree of factual basis for selection and placement of materials at the various grade levels.

"A great step in advance in the matter of sequence, came at about 1932 with the publication of the *Yearbook on Science.* As indicated before, this report viewed the question of sequence, not in terms of order of subjects, but in terms of developing appreciations of basic concepts. This work, although strictly speaking not the result of statistical research, was nevertheless, an important analytical study. Its implications for the question of science sequence have taken many years to realize in practice. Only now, in the year 1999, can we assume

to select certain concepts for Grade I, others for Grade II, and so on through the twelve grades.

"The early work in this field, such as the investigations of Craig in 1927 was concerned chiefly with a technique for selecting the essential generalizations of science. This technique, somewhat objective and statistical, utilized the opinions of educated laymen, educators and the popular writings of scientists. Other techniques, such as those developed by Downing sought justification for selected generalizations in the life problems and situations of individuals. From all this effort, there developed a set of principles that seemed acceptable to science educators.

"The next step in the development of a sequence, was to determine the grade placement of the different generalizations. Craig had shown the possibility of laying an experimental basis for certain concepts in Physics as far down as Grade I. Haupt in 1931 found possibilities in beginning a study of the Energy Concept in the early grades. Intensive work since then has accumulated data which give justification to our present practices. Many of our accepted generalizations appear in all grades, each grade providing science activities and experiences which build up finally into real and thorough understanding and skill."

"The next question we wish to put to you," said the Examiners, "is whether you teach by demonstrations or by organizing individual laboratory exercises."

"This is an unfair question," replied the prospective teacher of science. "I teach by both methods. To make my meaning clear, permit me to sketch briefly the history of this problem and some of the studies which have brought us nearer to a solution.

"When science first assumed a place in the curriculum it was called 'Natural Philosophy.' This was early in the nineteenth century. The great popularizers of science of that era, Davy, Faraday, Tyndall, Huxley and others, had developed a demonstration technique that had great appeal for the beginner and the uninformed. But as the sciences grew in specialization the laboratory became the means of progress. It was natural then, that at the beginning of the twentieth century, the individual laboratory exercise should assume a place of vital importance.

Schools were built, so that laboratory space was provided, special furniture was designed and expensive equipment was installed. When high school populations increased to such proportions that administrators and taxpayers could not continue the expense of laboratories and individualized equipment, the question arose, as to whether effective teaching could not be accomplished through teacher and pupil demonstrations.

"In 1918, Wiley reported the first investigation contrasting the outcomes of the two methods. His conclusions seemed to favor the demonstration method. Downing in 1925 reported the result of eight investigations which seemed to show again that demonstrations yielded better results in imparting knowledge quickly and economically. In 1927, Riedel reported on five of the eight investigations referred to above and two additional ones. His analysis pointed to weaknesses, scientific and statistical in nature, in all of the investigations to date. Riedel's own investigations were reported in 1933.[2] Kiebler and Woody in 1923 reported once more that the demonstration is as good, if not better than the individual laboratory exercise in Physics, and Johnson in 1928 reported the same conclusion in the field of Biology. Pruitt in 1925 investigated the question in the field of Chemistry; but arrived at conclusions which showed the individual laboratory method superior in certain respects. In 1925, however, Knox reported a series of investigations in chemistry which favored the demonstration method in such matters as meeting individual differences and retention of knowledge. His general conclusions seem to be upheld by Carpenter who reported at about the same time and who used a much more refined technique of experimentation. According to Carpenter, 'the majority of pupils in high school laboratory chemistry classes, taught by the demonstration method, succeed as well as when they perform the exercises individually, if success is judged by instruments which measure specific information.' Carpenter then urged a greater number of demonstrations but cautioned teachers not to expect from this method results which only the individual laboratory exercise could bring.

"In 1928 Horton presented the results of a thoroughgoing study of this question in the field of Chemistry. He showed with some degree of certainty that the individual laboratory exer-

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[2] The author is, of course, uncertain about this date.

cise, especially when it is organized on a problem basis, is to be preferred for certain valuable outcomes. Among the latter are skill in manipulation, improvement in method of thinking and in ability to solve problems. Horton found also, that for gaining in ability to answer written tests, demonstration work is as good as laboratory work; and, of course, more economical.

"Since 1930 the following point of view has prevailed:

1. That both the demonstration and the individual laboratory exercise should be employed in all science courses, each method to provide the outcomes peculiar to itself.

2. That for the sake of economy both in time and money, there should be a greater number of demonstrations than of laboratory exercises.

3. That the stereotyped laboratory manual fails in many respects to yield the outcomes for which laboratory work is especially adapted. Hence, laboratory exercises should be reorganized for the development of skills and for problem solving.

4. That each specific idea in science can probably be better taught by one rather than the other of the two methods."

"You have made several references to demonstrations as a means of economy," said the Examiner, "Is it not true that even greater economies can be effected if teachers of science will devise their own demonstration equipment with cheap and easily obtained materials?"

Our well-informed teacher of the year 1999 was somewhat taken aback by this question; but decided to meet the issue in this fashion:

"I can not agree altogether with this point of view. It is true that a simple demonstration with homemade materials is often more effective than a demonstration which employs expensive and complicated apparatus; but all investigations up to the year 1931 have pointed to other criteria for judging demonstrations than that of cheapness and 'homemadeness.' Throughout the history of science teaching there have been teachers who spent a major portion of their time in devising new and ingenious apparatus. Often the sole merit of these contributions was their novelty and the low cost of the equipment. Science education journals of the years 1910 to 1930 are filled with such demonstrations. When one asks of most of them, 'what worth-while experience do they bring to the pupil?' the answer is often negative or not obtainable. We have come to

recognize a danger in over-emphasizing this type of teacher activity. The difficulty is that the plaudits and praise which come to the teacher who devises new, though not necessarily experiential apparatus, are very attractive to him personally. However, they tend to divert too large a part of his energies from more important work.

"Teachers of science have a right to demand that certain pieces of equipment be purchased. Certainly, the basic supplies should be provided in variety and in quantity, so that demonstration set-ups are possible without resorting to pupil contributions and an invasion of the junk pile.

"All this does not mean that science teachers should not be skilled in devising demonstrations or that they should shun the objects which pupils bring in from their home laboratories and toy collections. There is a worth-while place for such materials in the many outgrowth and supplementary activities of classwork. Often a pupil's question can be answered most effectively by suggesting an experiment with cheap, simple, easily obtained or toy apparatus. The essential thought I do wish to convey is that the study of this field since 1925 indicates that science teachers must be provided with a teaching equipment. Expenditures of moneys are determined by the educational values which result from the apparatus in question.

"More important than economy of equipment is the development of effective techniques in demonstrations. The first analysis of such techniques appeared in 1930 and was the result of almost a lifetime of research by John Clark, teacher of Physics in New York City. Since that time others have given thought to the technique of the demonstration and the problems of equipment. Meister, in 1932 reported an analytical study in this field in which six investigations were proposed. Since 1932 most of these investigations have been completed. The proposed studies were as follows:

1. *A study to determine the available apparatus experiences for the teaching and learning of each of the important generalizations in science.*—Much of this material was easily available, but it was diffused in many textbooks and manuals, in magazine literature and in the classroom practices of teachers of science. There was great need for a single source book to which teachers of science could refer and in which they could find helpful de-

tails concerning possible apparatus experiences for each important topic of the courses in science. The book was a large one and a costly one. Its contributions to the teaching of science were not only of great value, but persisted for a long time.

The book classified apparatus experiences on four bases: (a) Those suitable for the demonstration table; (b) Those suitable for individual laboratory work; (c) Those possible with materials ordinarily described as 'homemade'; (d) Those possible with materials ordinarily purchased.

2. *A study to determine which of several available apparatus experiences is most effective in the teaching and learning of given science facts or principles.*—There were as many studies required as there are important generalizations in the various science subjects. The task was simplified by first developing a measuring technique. This technique was applied by many workers in different fields.

3. *An analytical study to determine the specific educative experiences possible with each of 100 commonly purchased pieces of science teaching equipment.*—The number set for this study was of course, arbitrary. It was necessary also to distinguish between pieces of equipment according to price range. A ready source of data and for assistance in an attack upon this problem were the companies that advertise and sell science teaching equipment to schools.

4. *A study to determine the types of science problems that pupils can solve through the use of science room facilities and equipment.*—There was great need for knowledge of this kind. In the course of every science lesson, the pupil raises questions. How shall they be answered? Many can be answered categorically by the teacher. Some are suited for supplementary reading by the pupil. Others are excellent for stimulating class discussion. Certain inquiries, however, yield the greatest educational return when the pupil is turned loose as an investigator. Such problem solving may utilize either the demonstration equipment or the laboratory facilities or both.

5. *A study to determine the relative value of different demonstration techniques.*—This was made necessary by the increasing emphasis upon teacher and pupil demonstrations. The evaluation as developed by this study established an effective demonstration technique, and suggested desirable changes in

the design and accessories of the demonstration table, the storage and organization of materials in the classroom and in seating and lighting arrangements.

6. *An analytical study of laboratory arrangements and the functions of laboratory furniture.*"

"When I was a boy," said one of the Examiners, "I studied science from a workbook. What is your judgment of that method of teaching?"

And the candidate for election to a science teaching position replied:

"The workbook in science teaching was a by-product of a classroom procedure that had great vogue in the period 1920-1935. In an attempt to adjust materials and rates of progress to individual differences among pupils the socialized recitation and the discussion-development lesson were abandoned by many teachers. The movement gained impetus from two other sources. One was the feeling that the study habits of pupils should be directed and the other was the Unit Plan philosophy of Professor Morrisson. All of these ideas were sound. Complete mastery in learning is a desirable goal; study habits are important elements in learning and each individual should be given an opportunity to achieve at his own optimum rate. But the flood of workbooks did not seem to achieve the desired ends. They brought certain evils with them. Pupil activity took on the aspect of 'busy work.' Inexperienced and lax teachers used workbooks as a crutch. Too often, the workbook fill-ins were mere reproductions of statements taken from the textbook references. Worst of all, many of the workbooks accepted without question a traditional and formalized course of study; thus mechanizing in teaching procedure a body of content already too mechanical.

"The workbook idea, however, has not been altogether abandoned, largely because of a number of investigations in the fields of directed study and individual differences. For example, Beauchamp's study of technique in the mastery of subject-matter in elementary physical science, showed that specific training in getting the central thought of a paragraph and in framing questions one must be able to answer in order to understand a topic, results in better understanding than undirected study of the same material. Persing's study of paragraph summarizing in Chemistry developed evidence which indicated agree-

ment with Beauchamp. Cunningham's report on types of thought questions in textbooks and manuals pointed to the need of training pupils in answering a wide variety of questions. Also, Hurd's study of the relative value of the topical *vs.* the problem method in acquiring information in Physics, urged a direct attack upon subject matter rather than learning through problem-solving. Of course, not all investigations of this subject were in agreement. Robertson's study in 1930 of the relative values of the 'study-guide' method and the development-discussion method, resulted in data which favored the latter method. Similarly, Corbally's investigation in 1930 comparing the effectiveness of the Unit Plan with that of the assignment-recitation plan seemed to indicate that the determining factor is the teacher, not the method. Nevertheless, the conviction has persisted that there is a place in teaching procedures for a guide sheet of pupil activity. As a supplement to discussion developments of large concepts and as a self-testing and drill device, the workbook idea is still functioning and will probably continue to do so.'

"This is the final question," said the Examiner. "What is the proper function in teaching method of the many visual and auditory aids to instruction; as for example, the motion picture, the talkie, the radio and television?"

With a sigh of relief, our prospective teacher of science tackled his last assignment:

"Ever since the time of Comenius, teachers have recognized that ideas can be presented better by pictures than by words. The educational philosophers who followed Comenius also stressed the vitalization of the teaching process through the use of illustrations and concrete experiences. But the art of objective presentation did not spread rapidly. Teachers of science were, perhaps, the first to make use of demonstrations in teaching; but their methods seemed to be limited to a special set of experiences peculiar to their subject. Then, in the first quarter of the twentieth century, came a flood of inventions. An electric lamp, powerful enough to use in a projection machine, new processes in photography and printing, the motion picture, the phonograph, the talkie, the radio and finally television. Strangely enough, subjects other than science were the first to welcome these new devices as aids to instruction. Perhaps, the science teacher did not at first see in these instruc-

tional aids anything that could seriously compete with actual demonstrations and laboratory work. But as time went on, the interest of science educators was attracted to this field.

"In 1929, Freeman and Wood published their study, conducted for the Eastman Kodak Co. In a carefully controlled experiment with more than 3,000 children in 12 different schools, they attempted to measure the value of silent motion picture films in teaching general science. The essential results of this work was not so much to point to a tremendous statistical superiority in achievement through the use of films, as it was to point to new procedures for science teaching in this field.

"When in 1930 sound was first added to the motion picture, using science subject matter, teachers were enthralled with the possibilities. These early talkies, imperfect though they were, brought real experiences into the classroom. In many respects they were almost as good as actual first hand experiences and in certain respects they were superior. For the first time there was created a way by which city children could, in effect, be taken out into the country, to see sights and to hear sounds that supplemented deficiencies in their environment. Similarly rural children could in a moment be transported to large centers of population; and all children could travel vicariously to distant places in order to gain educative experiences.

"Of course, many abuses of these new teaching instruments followed. It was a long time before the radio as a means of education was developed, so that it could serve the schools effectively. Even today we are faced with a problem of proper control of television facilities. Nevertheless, teachers of science, as of all subjects, should and do supplement their work with these aids to instruction.

"Our present practices in this field are largely determined by a series of studies suggested in the *Yearbook of 1932* and conducted in the years that followed. These studies were worded as follows:

1. *A study to determine the available screen experiences for the teaching and learning of the important generalizations in science.*—This study developed a compendium or source book of material which has been kept up-to-date.

2. *A study to determine which of several available screen experiences is most effective in the teaching and learning of given science facts or principles.*—The same criteria employed

for evaluating a piece of apparatus or a demonstration experiment were used in evaluating charts, sets of slides, motion pictures and talkies. Radio programs and television broadcasts were also subjected to the same critical examination from the teaching and learning point of view and in terms of the important generalizations which constituted the science curriculum and sequence."

All will agree that the candidate for a science teaching license deserved to pass, and with honors. If there are any who feel that the situation as described is somewhat artificial, and that such an individual could not possibly exist, the writer pleads guilty and offers apologies. Yet, the thought comes to mind, whether in the year 1999 our training of teachers of science may not have developed to the point where candidates for admission into our profession shall be expected to be erudite in subject matter, in educational history and in teaching techniques.

Parenthetically, it may be said that among the many recent educational investigations in science teaching which have *not* been mentioned in this paper are those that have to do with the training of science teachers. This has been done consciously not only because of time limitations; but because of the paucity of thought and effort which have thus far been given to the problem of preparing science teachers for the various levels. Perhaps, five years from now, when the many institutions recently organized for this specific job, have been able to reflect on their experiences, a significant discussion of teacher training in the sciences can be held with profit. We should all look eagerly to the outcomes of such schools as the Montclair State Teachers College and the newly projected teacher-training college of Columbia University, which is to begin next fall under the leadership of Dr. Alexander.

The writer must also take occasion to say that in mingling actual and recent research with his own personal "stabs in the dark" he has tried to exercise restraint. It is easy to paint a rosy and fantastic future for any field by totally disregarding the present, from which the future flows by a process of cause and effect. Thus, in every phase of science teaching which he has attempted to discuss due emphasis was attached to history and development, to recent efforts of investigation and to probable trends of growth for the future. The choice of the year

1999 is of course arbitrary and might be put at any time greater than two decades hence.

Finally, the writer wishes to mention a recent publication dealing with research in science teaching which should be read and discussed wherever science teachers get together. Certainly no discussion of a subject such as is included in this paper can afford to omit a reference to Curtis' *Second Digest of Investigations in Science Teaching.* This book continues the point of view and procedures developed in the *First Digest of 70 Studies,* published in 1925, adding 93 new ones in the second volume. The selection of these 93 studies was made from a collection of hundreds, by a vote of the National Association for Research in Science Teaching. Much of the material presented in this paper was drawn from this book and to it I should refer anyone for significant omissions from the list of studies mentioned.

Although this may seem to be an unqualified recommendation of a book, it should not be construed as an endorsement of all the studies included in and reported by the book. From the point of view of accuracy and scientific method many of the studies are distinctly weak. Of some, one is moved to admonish the author that "experimenting does not absolve the scientist from the duty of thinking." Of others, one is forced to conclude that science cannot come by mere industry on the part of the investigator.

Curtis himself analyzes the weaknesses in certain of the studies in a masterly preface which indicates 13 tendencies toward error. At the same time, we should not be cynical or pessimistic. The method of science is not rapid; it takes longer to formulate a law than an opinion. Twenty years ago there were practically no studies in the field of science education. Science curricula and class procedures were altogether based on opinion, tradition and limited experience. Today there exists the problem of selecting studies from a vast number already made. Twenty years is a long time in the professional life of a teacher, but it is only a moment in the history of education. The investigations of the last two decades have cast a circle of light on a field which has for a long time been in darkness. If this circle is small, if its outlines are as yet hazy, it is nevertheless a source of satisfaction to those who believe in a science of education. Viewed from a distance this circle

of light contrasts sharply with the surrounding darkness, distinguishing what is known from that which is unknown. Viewed at close range, it is difficult to determine where the light ends and the darkness begins. However, the cure for poor science is more science.

Those who work in the field of science education should dedicate themselves to the proposition: (a) That there is such a thing as artistic teaching; (b) That the outcomes of artistic teaching can be measured in terms of pupil learning; (c) That the procedures employed by artistic teachers can be analyzed and made the basis for a science of teaching; and (d) That progress in science teaching can come only by an acceptance of this science of teaching by all teachers of science.

IMPROVING READING IN BIOLOGY

By Kermit J. Blank, *Lehigh Township High School, Walnutport, Pennsylvania*

One of the foremost causes of failure in any subject, but in the Sciences and Mathematics particularly, is the pupil's inability to read well. Reading well includes not only reading at a maximum rate, but also with a maximum of comprehension. If, for example, a person should be an extremely rapid reader, but a poor comprehender, it would be logical to try to improve comprehension even at the expense of rate. Not that the advantage of reading rapidly should be submerged, but that the more desirable trait of comprehending well should be encouraged. In the same manner, a person who reads slowly, but comprehends well should increase his rate of reading. The process of increasing rate should be gradual so that high comprehension may be maintained. The procedure which follows can well be adapted to any high school class and will prove a valuable aid in better teaching.

I. Measuring rate and comprehension at the beginning of the term.—The pupils were assigned a certain portion of their text to read for practice. (No records were kept from this trial.) Another portion, not the same topic, was then assigned. The pupils read for three minutes after which each one counted the number of words he had read. A record of this appears in the table under the column marked Rate I. Before the test

all the facts in the topics read had been picked out and arranged in a table of questions in such a manner that each person answered questions on those facts which he had read. For example, pupil No. 28 read 618 words in three minutes; there were in those 618 words 17 facts, therefor he answered 17 questions. Of the 17 attempted 10 were correct, therefore his comprehension was considered 10/17 or 59 per cent.

The results of this first measurement of Rate and Comprehension appear in the table under Rate I and Comprehension I. It will be noted at the bottom of the table that the median rate was 197.5 words per minute, while the median score in comprehension was 59.71 per cent. In other words, the median pupil in this group read 197 words per minute and comprehended about 60 per cent of what he read.

II. Diagnosis.—In glancing over the table it will be seen that range of speed in reading varied from 90 words per minute in the slowest pupil to 342 words per minute in the fastest pupil. This would indicate the necessity of special drill in reading for the slower persons.

The column marked Comprehension I shows that the range of comprehension varies from 34 per cent of the facts in the slowest person to 93 per cent of the facts in the highest person. This indicates the need for more purposeful reading on the part of the lower pupils.

It would be relatively easy to treat a situation such as is shown here if it were possible to organize the defective students into a special reading class, but since most schedules lack space for the like, the remedial work that is undertaken must be included in the regular class work. Individual work will be very limited, since the measures taken must apply to the class as a whole.

III. Remedial Measures.—In remedying a situation such as this, assignments must be planned so as to help both types of cases. Some of the devices for improving thinking in reading and hence comprehension were (1) Study helps were given with a number of assignments, not everyday however. These helps served to pick out main points and acted as a very definite assignment. A continuous use of such a device might defeat its own purpose as the students may become dependent. (2) Outlines were resorted to at intervals. In order that these outlines could be made the student had to know the complete organization of the assignment. If the organization of the assignment

Pupil	Rate I	Rate II	G	Comp. I	Comp. II	G
1	217	271	54	50	70	20
2	183	240	57	63	92	29
3	200	234	34	50	75	25
4	262	363	100	72	75	3
5	234	282	48	58	80	22
6	136	170	34	71	80	9
7	278	225	−53	46	50	4
8	133	271	138	38	62	24
9	202	167	−35	34	82	48
10	217	345	128	61	72	11
11	168	212	44	59	70	11
12	158	219	61	81	78	−3
13	187	239	52	52	75	23
14	169	211	42	50	62	12
15	213	308	195	50	80	30
16	143	222	79	73	86	13
17	160	235	75	88	88	0
18	172	255	83	56	62	6
19	209	250	41	64	88	24
20	181	205	24	63	90	27
21	218	233	15	57	75	18
22	157	247	90	75	88	13
23	228	239	11	65	87	22
24	132	157	25	54	80	26
25	171	220	49	56	68	12
26	234	228	−6	48	76	28
27	226	238	12	65	83	18
28	206	244	38	59	50	−9
29	249	235	−14	83	94	11
30	203	193	−10	68	85	17
31	158	285	127	75	82	7
32	117	175	58	50	50	0
33	143	225	82	79	75	−4
34	318	304	−14	90	85	−5
35	290	225	−65	74	75	1
36	211	225	14	50	62	12
37	338	225	−113	69	90	21
38	90	84	−6	56	25	−31
39	342	300	−42	58	86	28
40	183	263	80	89	90	1
41	147	225	78	93	91	−2
42	155	232	77	88	90	2
43	172	190	18	50	78	28
L.R.	90	84	−6	34	25	−9
Q1	158.13	215.63	57.5	53.15	71.46	18.31
M.	197.5	236.8	39.3	59.71	80.33	20.62
Q3	224.43	256.25	31.82	73.93	87.5	13.6
H.R.	342	363	21	93	94	1

was fixed, then, surely thinking must have taken place. (3) Special reports were given to people whose comprehension was low. This work required stating in a minimum of words the thoughts contained in a lengthy discussion. (4) Thought provoking questions were asked in class; this served to raise comprehension in reading because it stimulated thinking. (5) Frequent short tests (new type) served to stimulate reading for thought. (6) Topic indentions, stating the main point dealt with in a certain paragraph, were made for various parts of the text. These, too, stimulated thought in reading.

Some of the devices used for increasing rate of reading were as follows. (1) Interesting supplementary material was kept at hand. Frequent assignments made this reading a necessity which to many of the students proved very entertaining since the type of material used was light and interesting. Among the books used were the following: Dr. Gulick's *Efficient Life*, Hornaday's *Natural History,* DuPuy's *Insect Friends and Foes*, etc. (2) Pupils were encouraged to read such magazines as *Nature, Bird-Lore, Hygeia, Scientific American* and other scientific magazines that might prove of value. Special credit was given for evidence of such reading. (3) Questions were given to the students whose work it was to find the answers in the text. This caused them to read rapidly as each one wanted to find the answer first.

The effectiveness of these measures can be seen by consulting the table. The "G" column represents the gain of the second test over the first.

IV. Measuring the Improvement.—After a period of four months during which time the foregoing remedial work was in progress, a second test was given. The test was run exactly the same as the first one with the exception that the material read was different, but of the same degree of difficulty. It can clearly be seen that the remedial measures had a good effect on both the rate and the comprehension. By referring to the "G" column it will be seen that the rate was bettered by 39.3 words per minute. The median comprehension score was raised 20.62 per cent. These results are tangible evidence of the value to the class as a whole. As has been stated before, the ideal way would be to study each case individually, but where this is impossible class study will serve as a very admirable substitute.

A QUANTITATIVE TEST OF THE CONSERVATION OF ANGULAR MOMENTUM

By JOHN MEAD ADAMS, PH.D.
University of California at Los Angeles

It is a consequence of Newton's laws of motion that a mechanical system rotating about an axis must retain its angular momentum unchanged so long as no external torque is applied to the system. This statement is known as "the principle of the conservation of angular momentum." Angular momentum is the product of moment of inertia by angular velocity, and in the circumstances just described any decrease of the moment of inertia must bring about a corresponding increase in the angular velocity, in order that the product may remain constant. In astronomy the principle requires that the rate of rotation of a star on its axis shall increase as the star shrinks in diameter; and it is a familiar lecture-room experiment to stand upon a rotatable stool with arms outstretched and while rotating slowly to bring the arms down to the sides, thereby acquiring a spectacular increase in the speed of rotation.

An apparatus designed by the author admits of making quantitative tests of the principle, the experiment being suitable for college classes in elementary mechanics. The apparatus consists essentially of two equal masses sliding freely on a horizontal rod, with a spiral spring connecting them, and with an electromagnetically operated catch to hold them against the tension of the spring when they have been withdrawn to the ends of the rod. The whole is suspended by two equal parallel vertical wires to oscillate rotationally as a bifilar pendulum, the wires serving also to carry the current operating the catch. While the apparatus is oscillating, and just at the middle of its path where the applied torque is zero, the catch is released, the masses spring together, and the corresponding sudden increase in speed is made evident by a decided increase in the amplitude. The conditions may be varied by altering the travel of the masses by a movable stop and by starting with a different amplitude.

The theory upon which the quantitative test depends is as follows.

Let M = mass of the entire apparatus,

l = length of either wire,

$2b$=distance between the wires,

g=acceleration of gravity,

I_1=moment of inertia of the entire apparatus before releasing the catch,

T_1=period of oscillation before releasing the catch,

θ_1=amplitude of oscillation before releasing the catch,

ω_1=angular velocity of the oscillation at the mid-point of the path before release,

I_2, T_2, θ_2, ω_2 =corresponding quantities after releasing the catch.

Then the bifilar formula gives

$$T_1 = 2\pi\sqrt{\frac{I_1 l}{Mgb^2}} \tag{1}$$

and the relation in simple harmonic motion connecting the period and the maximum velocity of the oscillation with the circumference of the circle of reference gives

$$T_1\omega_1 = 2\pi\theta_1. \tag{2}$$

The angular momentum at the mid-point of the path before release $I_1\omega_1$, is then obtained from (1) and (2) as

$$I_1\omega_1 = \frac{T_1\theta_1 Mgb^2}{2\pi l} \tag{3}$$

and the angular momentum at the same point after release is similarly obtained as

$$I_2\omega_2 = \frac{T_2\theta_2 Mgb^2}{2\pi l} \tag{4}$$

These two quantities of angular momentum should, according to the principle, be equal, since the change by which the first passes into the second is made on a system while in rotation free of any external torque. Equations (3) and (4) show that $I_1\omega_1$ and $I_2\omega_2$ will be equal if, and only if, $T_1\theta_1 = T_2\theta_2$. The quantities to be observed in the experiment are therefore the periods before and after release, and the amplitudes before and after release; and the principle of the conservation of angular momentum is tested by examining the constancy of the product of period by amplitude before and after release.

The data and results obtained in several tests of the first apparatus constructed are appended.

T_1	θ_1	T_2	θ_2	$T_1 \times \theta_1$	$T_2 \times \theta_2$	Discrepancy
5.88 sec.	11.4°	4.33 sec.	15.3°	67.0	66.3	1 per cent
5.88	12.8°	4.64	16.0°	75.2	74.3	1.2 per cent
5.88	15.05°	4.59	19.1°	88.6	87.7	1 per cent

All the tests made with this apparatus show a similar discrepancy, consistently indicating an apparent loss of about 1 per cent in the angular momentum. This is attributable to the fact that the sliding masses when released take up their new positions in a time which is not negligible in comparison with the period of the oscillation. It may be possible to improve this feature of the design.

The necessary precautions to be observed in performing the experiment relate to the correct timing of the release, which should occur accurately at the mid-point of the path; and to the use of a small amplitude of oscillation, in order that the period (with a fixed moment of inertia) may be independent of the amplitude. The largest admissible amplitude will depend upon the degree of accuracy desired and upon the lengths *l and 2b*. Some preliminary measurements of T with different amplitudes will indicate the limit of amplitude in any given case.

VISUALIZING TRIGONOMETRIC TABLES

By L. E. McAllister, *Berry College, Mount Berry, Ga.*

Many teachers in presenting the use of trigonometric tables to a class realize that the pupils think of the tables as very little more than groups of numbers. When a student looks up Cos30° and finds it to be .866, it means .866 and nothing more unless the subject is presented in such a way as to give it real meaning. The writer uses the devices shown in FIGURE 1 and FIGURE 2 and finds them helpful.

I

A QUANTITATIVE VISUALIZATION OF TRIGONOMETRY

In the October, 1931, issue of SCHOOL SCIENCE AND MATHEMATICS, the writer shows and describes a working device for "Visualizing Trigonometry" in a rather qualitative manner. Since that article was written the device has been developed to do more things and at the same time to show them in a more quantitative way.

CONSTRUCTION

Consult FIGURE 1. White glazed cardboard (20″ x 28″) is fastened to a wooden board. The following lines are drawn with black India ink: (1) a circle of 18 cm. radius, (2) the X-axis (XX′), (3) the Y-axis (YY′), (4) a tangent to the circle at C (full length of cardboard) and (5) a tangent to the circle at D.

Fig. 1.
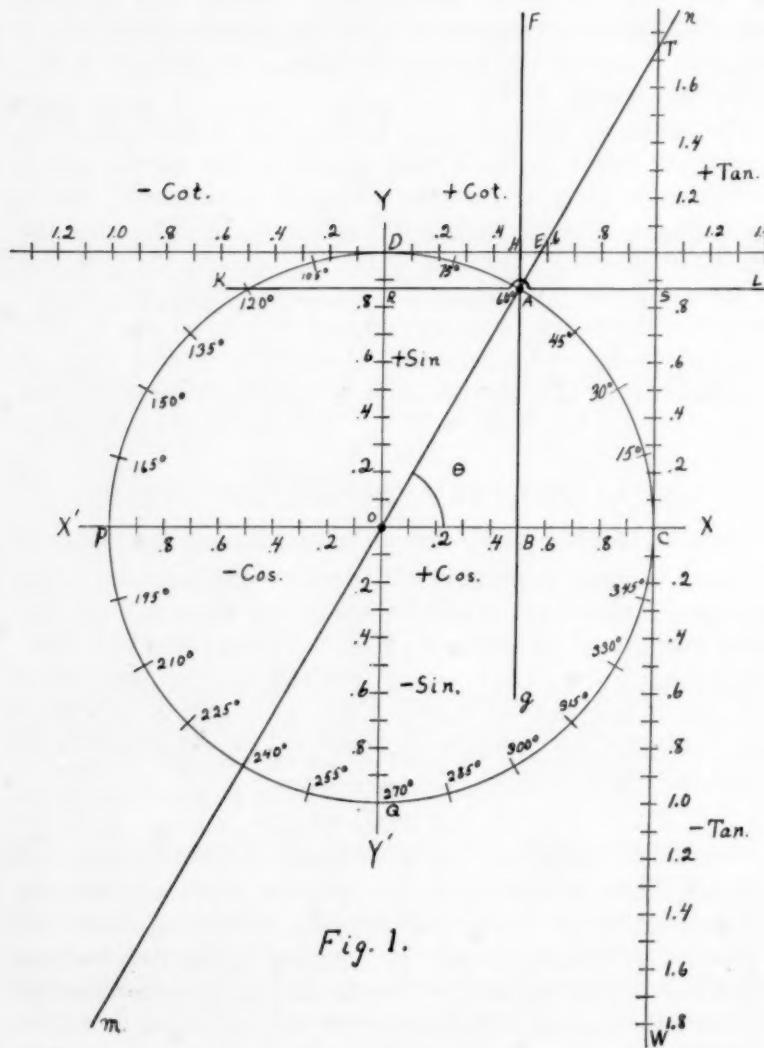
The line *mn* is a ⅛ inch iron wire about a yard long with holes bored at *O* and *A*. A nail is driven through into the board at *O*, so the wire will be free to rotate around that point. The line *Fg* is a #10 copper wire, 19 inches long, with a hole bored at *A* and fastened to *mn* by a rivet fitted loosely enough to allow free rotation. The wire should hang in a vertical position due to the fact that *Ag* is longer than *AF*. The line *KL* is a #18 copper wire, 15 inches long, fastened to *Fg* a little above *A* by passing through it very tightly (the two wires could be soldered together). *KL* is bent so as to be straight, horizontal, and on a level with *A*.
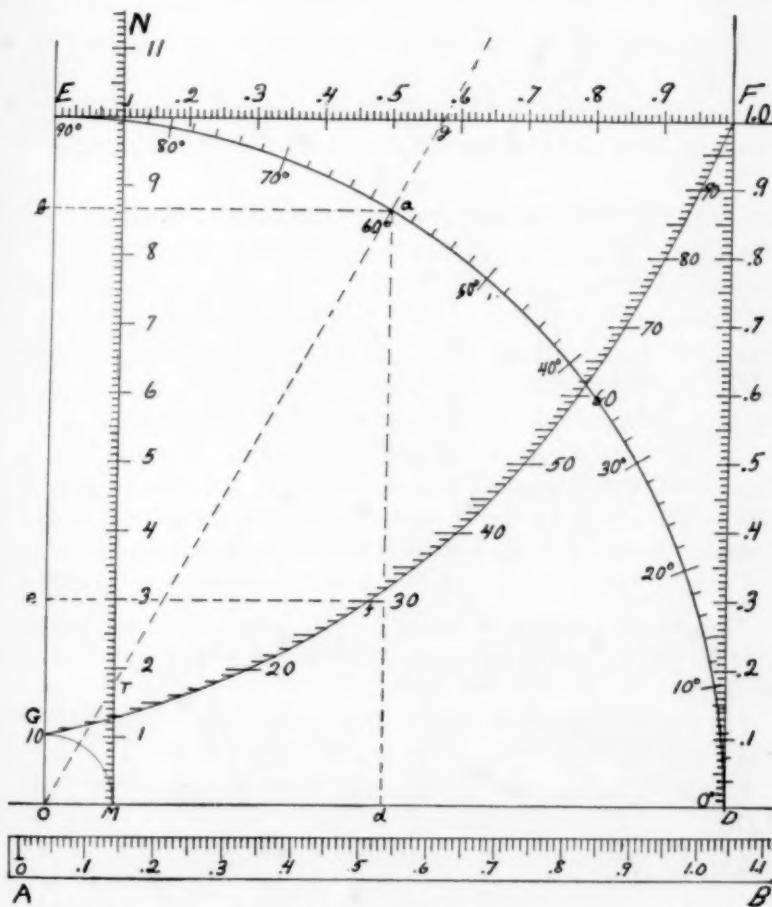
Fig. 2.

THEORY

If the radius of the circle is considered as unity, the values of the six trigonometric functions are represented in the following way:

TABLE 1

Function	Line value	60° value	When negative	Quadrants negative
Sine	$BA = OR = CS$	.866	Below X-axis	3rd and 4th
Cosine	$OB = DH$	.500	Left of Y-axis	2nd and 3rd
Tangent	CT	1.73	Below X-axis	2nd and 4th
Cotangent	DE	.577	Left of Y-axis	2nd and 4th
Secant	OT	2.00	T between O and m	2nd and 3rd
Cosecant	OE	1.15	E between O and m	3rd and 4th

USE

By rotating the wire mn around the point O and keeping the wire Fg as nearly vertical as possible, the following (see table 2) may be observed as the angle Θ increases from $0°$ to $360°$. One may stop and observe the function values at any angle.

TABLE 2

Function	Value	Moving point	Letter and Numerical Cycles
Sine	OR	R	O to D, D to O, O to Q, Q to O—Letters
			O to 1, 1 to O, O to −1, −1 to O—Values
Cosine	OB	B	C to O, O to P, P to O, O to C
			1 to O, O to −1, −1 to O, O to 1
Tangent	CT	T	C to ∞, −∞ to C, C to ∞, −∞ to C
			O to ∞, −∞ to O, O to ∞, −∞ to O
Cotangent	DE	E	∞ to D, D to −∞, ∞ to D, D to −∞
			∞ to O, O to −∞, ∞ to O, O to −∞
Secant	OT	T on mn	C to ∞, −∞ to C, C to −∞, ∞ to C
			1 to ∞, −∞ to −1, −1 to −∞, ∞ to 1
Cosecant	OE	E on mn	∞ to D, D to ∞, −∞ to D, D to −∞
			∞ to 1, 1 to ∞, −∞ to −1, −1 to ∞

Many trigonometric relations may be obtained from the device in any quadrant desired. The following will serve to illustrate:

(1) Use triangle AOB, $AB^2 + OB^2 = OA^2$, $AB = Sin\theta$, $OB = Cos\theta$, and $OA = 1$. Therefore: $Sin^2\theta + Cos^2\theta = 1$.

Similar relations may be obtained from triangles TOC, and EDO.

(2) By comparing similar triangles AOB and TOC,

$$\frac{AB}{OB} = \frac{CT}{OC}, \text{ Therefore: } \frac{Sin\theta}{Cos\theta} = \frac{Tan\theta}{1}$$

(3) Again using triangles *AOB* and *TOC*:

$$\frac{OB}{OA} = \frac{OC}{OT}, \text{ Therefore: } \frac{\text{Cos}\theta}{1} = \frac{1}{\text{Sec}\theta}$$

(4) Such relations as $\text{Sin}(180 - \theta) = \text{Sin}\theta$ and $\text{Cos}(180 - \theta) = -\text{Cos}\theta$ are very easily obtained by rotating the point *A* into one of the other quadrants. By using triangles *AOB* and *AOR* it is easy to see that $\text{Sin}(90 - \theta) = \text{Cos}\theta$, etc. Any good trigonometry teacher would be able to show all trigonometric relations except those complex relations such as the functions of the sum or difference of angles or of multiple and half angles.

The dimensions of the apparatus as described here need not be followed in detail by anyone trying to construct it. The choice of dimensions must depend on the size of cardboard and mounting board available and the distance it must be placed from the pupils in the classroom.

II

GRAPHIC TRIGONOMETRY AND LOGARITHM TABLES

The device described in part I is very limited as to accuracy because of the relative shortness of the graduated lines. In FIGURE 2, the accuracy is about one significant figure greater because the scale is larger due to the fact that only the first quadrant is used. The accuracy is about the same as that of a good 10 inch slide rule, but the class can see better what you are doing. Here, instead of movable wires that are too wide for accuracy, a separate scale *AB* is drawn on a strip of cardboard about 1 inch wide and long enough to reach from *O* to *F* diagonally across the chart. The *AB* scale is used just as if it were a meter stick.

CONSTRUCTION

1. The chart is drawn with black India ink on white glazed cardboard 22 by 28 inches. The origin is a *O*, *OD* = *X*-axis, and *OE* = *Y*-axis.

2. The arc *DE* has a radius of 50 centimeters. It is marked at each degree and numbered at each 10°. The degree marks are about 9 millimeters apart, making visibility quite good over an ordinary classroom.

3. The line *DF* is the tangent line to be used from 0° to 45°. Above 45° scale *MN* is used for reading tangents.

4. The line *EF* is the cotangent line used between 45° and

90°. Below 45°, use $\text{Cot}(90 - \theta) = \text{Tan}\theta$ and look up the tangent.

5. The line *GF* is a logarithm curve plotted with the ordinates representing numbers in the same scale as on *MN* and the abscissae representing the mantissae of the corresponding logarithms on the *AB* scale.

6. A strip of picture frame molding may be tacked along the top to which hooks for suspension may be fastened. A small nail at one end of the molding will suffice to hold the *AB* scale when not in use.

USE

Table 3 shows how the chart is used for a 60° angle. For any other angle imagine the point "a" moved to the number on the circular scale representing the desired angle.

TABLE 3

Function		Line measured	How measured
Sin60°	= .866	*ad*	Use *AB* scale
Cos60°	= .500	*ba*	Use *AB* scale
Tan60°	= 1.73	*MT*	On *MN* scale
Cot60°	= .577	*Eg*	On *EF* scale
Sec60°	= 2.00	*OT*	Use *AB* scale times 10
Csc60°	= 1.15	*Og*	Use *AB* scale
Log 3	= 0.477	*ef*	Use *AB* scale

The anti-functions are obtained by measuring off given function values and reading on the circular or logarithm curve. The log-trig values are obtained by reading first the trig function and then the log of that. Care must be taken that students do not get the idea that the trig functions are distances instead of ratios.

PROPOSED AMENDMENT TO THE BY-LAWS OF THE C.A.S. AND M.T.

Article V, Section 4. Insert the words "Elementary Science" following the word "Chemistry." This Section will then read as follows:

Section 4. Professional Sections: The association shall be divided into sections as follows: Biology, Chemistry, Elementary Science, General Science, Geography, Mathematics, and Physics. Each section shall be composed of members of the Association who are especially interested in the subject of that section. The organization and activities of the sections may be amended from time to time by the Board of Directors. Unless otherwise provided by the Board of Directors, each section shall elect its own Chairman, Vice-Chairman and Secretary.

THE USE OF THE SHORT-ANSWER TYPE QUESTION IN PROVIDING STUDY HELPS FOR THOSE WITH READING DIFFICULTIES IN SCIENCE

By H. K. MOORE

Thomas A. Edison School, Cleveland, Ohio

More students from the lower ability levels are taking high school work than ever before. Most of these have great difficulty in following the difficult language of the current texts and reference books in chemistry and physics. This type of student when turned loose on the old type of text book page or formal outline assignment is lost. It becomes necessary for the teacher to place in the hands of the pupil something which will aid him in comprehending the meaning of the words he reads. The method used in Cleveland's problem boy school utilizes the short-answer technique.

This device is borrowed from the educational measurement field. If one were measuring, the questions would be called the "simple recall" type. While our use of this device is largely non-measuring yet it will assist the teacher in locating the source of the pupil's difficulty in the comprehension of a topic. The material to be studied is divided into units. The questions are composed over the unit so that the answer may be given in one or two words at the end of the question. If the student comprehends the material he can find and write in the correct answer. If he cannot do so the teacher knows at once where help is needed. The device is a help to the pupil in selecting the essentials from the discussion. The student is not swamped with an author's words when he knows what to look for.

The checking of the student's answers is easy. Answers can be prepared beforehand and the labor of checking performed by student clerks in those classes using individual instruction. In other classes the papers can be marked by the class and those questions most often missed used as a basis for class discussion. Teachers will be surprised at the small number of questions incorrectly answered since the device is in itself an aid to understanding.

In order to get an idea of the results of this method of studying the Edison 10th grade Chemistry class was given two forms of the Iowa Placement Examinations in Chemistry covering

the work of the first semester 1931-32. The Chemistry Aptitude Test was given on September 11, 1931. The Chemistry Training Test was given on January 7, 1932. It was found that practically every member of the class received the same score in January after one semester that he would be expected to receive, with his ability, in June after a full year's work. Those who entered the school or withdrew from school during the semester are not included in these results. The results become more striking when we note that these were not normal boys but problem boys.

In order to give a clearer idea of the method a brief sample is given from "Chemistry Assignments" used in Edison school.

CHEMISTRY ASSIGNMENTS

How to do the work.—You are to be given regular work in chemistry. It will be as valuable to you as you wish to make it. You will be permitted to progress just as fast as you are able. Frequent tests will be given.

Assignments will be given to you. These assignments will tell you just what you are to do. Follow the directions in each assignment carefully.

The successful completion of each assignment will be recorded in the storekeeper's book. After a certain number of assignments are completed you will be given two tests requiring a mark of 100 per cent on each. One test will be given and marked by the storekeeper. The other will be given and marked by the teacher. Successful completion of these tests will be recorded on the big chart. A test will also be given at the end of the semester to measure what you have learned.

Assignment 1.—Reference: Greer and Bennett, Chemistry. Read the foreword, pp. ixf. Then look up and write in the answers to these questions:

1. How much is each day of high school worth to you? . . . .
2. What is rule 5 for studying? . . . .

Assignment 2.—Read pp. 1 to 20 in Greer and Bennett, Chemistry. Do experiments 1, 2, 3, 4, and 6. Then look up and write in the answers to these questions:

1. Substances which burn readily are said to be . . . .
2. A fuel is something that . . . .
3. A second essential for burning is . . . .
4. Before they will begin to burn all fuels must be . . . .
5. Before it will begin to burn a piece of paper must be raised to its . . . .
6. When a candle burns these two substances are formed: . . . . and . . . .
7. Anything which has a definite shape and definite volume is a . . . .
8. If a substance has no definite shape but does have a definite volume it is a . . . .

9. A substance which has neither definite shape nor volume is a ......
....

10. In what state of matter is coal? ....

11. In what state of matter is air? ....

12. In what state of matter is vinegar? ....

13. What new product of burning is formed when magnesium burns?
....

14. The products of burning when compared in weight with the thing burned are ....

15. When a fuel burns it unites with something from the ....

16. .... and thus becomes ....

17. The something from the air with which fuels unite is ....

18. When any substance burns, it unites with ....

19. and we say that what is taking place is the process of ....
....

20. Oxidation becomes combustion or burning when it is accompanied by .... and ....

21. The proper mixture of oxygen and gas in the gas burner results in a flame which is (color) ....

22. The essentials for combustion removed when water is poured on a fire are .... and ....

23. Is water used to put out gasoline fires? ....

24. Cloth may be fire-proofed by dipping in a solution of ....
....

25. Wood may be fire-proofed by dipping in ....

26. A fire-proof cloth made from a mineral is ....

27. Lime-water is used for testing ....

28. Is combustion always oxidation? ....''....

29. Is oxidation always combustion? ....

Take your answers to assignments 1 and 2 to the storekeeper. He will mark each one right or wrong. You will be given your paper to make any corrections necessary. When all the answers are correct the storekeeper will record the fact in his record book. Then you are to begin assignment 3.

OTHER REFERENCES ON ASSIGNMENT 2

WOOD AND CARPENTER, *Our Environment, How We Use and Control It,* Chapter V.

CALDWELL AND CURTIS, *Introduction to Science,* Chapter XIII.

WASHBURNE, *Common Science,* pp. 312-25.

MCPHERSON AND HENDERSON, *Chemistry and Its Uses,* Chapters I and II, and p. 20ff.

Bacterial wilt of corn, a disease that as a rule does not assume serious proportions, has been doing material damage during the past season, the U. S. Department of Agriculture reports. In Illinois, it has so seriously damaged fields of sweet corn planted for the canneries that many of them were plowed up and replanted to other crops while the corn was still young. It also caused serious trouble in dent corn. New England sweet corn fields were damaged, some of them to the extent of 25 or 30 per cent.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison

State Teachers College, Kirksville, Missouri

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS OF PROBLEMS

Editor.—persons sending in solutions should read carefully the instructions about the form of the solutions and the ink-drawn figures. Many times, a good solution is received, but poorly arranged and no India-ink figure given.

LATE SOLUTIONS

1219, 1220.   *Gunther Wunsche, Dresden, Germany.*

1195.   *Proposed by E. C. Kennedy, El Paso, Texas.*

In a right triangle CAB, AC 3956 miles, AB 50 miles. With C as a center, a circle is drawn through A tangent to AB and cutting the hypotenuse BC at D. Find the length of arc AD to within an error of 0.1 inch, using a five place table to obtain angle C.
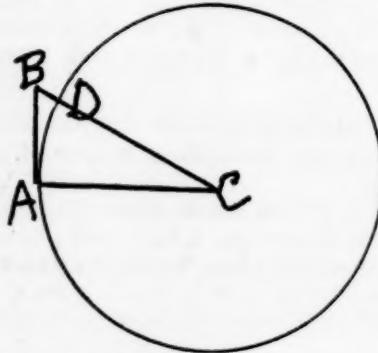
Solution by proposer

Arc $AD = 3956\ C$, where C is in radians, and $C = .01264$ rad.
Tan $C = C + C^3/3$, quite accurate when C is small.
$AB = 3956 \tan C = 3956(C + C^3/3)$.

So, $AB - \text{arc } AD = 3956(C + C^3/3 - C) = 3956C^3$
$$= .002662 \text{ miles} = 14.06 \text{ feet}.$$
Therefore arc AD is 14.06 feet less than 50 miles.

NOTE—This problem was offered for solution some time ago. This is the first solution submitted. EDITOR.

1229. *Proposed by the Editor*

In two triangles if a side and an angle of one are equal respectively to a side and an angle of the other, and if the angles opposite the equal sides are supplementary, then the sides opposite the equal angles are equal.
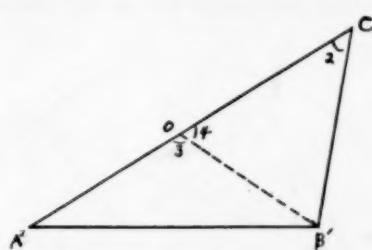
Solution by William Wegner and Edwin Beggs. The Lewis and Clark High School, Spokane, Washington

HYPOTHESIS: $AB = A'B'$ $\angle A = \angle A'$ $\angle C$ is the supplement of 2

CONCLUSION: $BC = B'C'$

STATEMENTS:

1. Superimpose $\triangle ABC$ on $\triangle A'B'C'$ so that ABC takes the position $A'B'O$.

2. $\angle C = \angle 3$ and $\angle 3$ is supplementary to $\angle 2$.

3. Also $\angle 3$ is supplementary to $\angle 4$.

4. Then $\angle 2 = \angle 4$.

5. Hence $\triangle OB'C'$ is isosceles.

6. And $B'O = B'C' = BC$.

Also solved by W. E. Buker, Leetsdale, Pa.; A. J. Patterson, Wheeling, W. Va.; R. T. McGregor, Elk Grove, California; Andrew Sobczyk, Duluth, Minn.; D. Moodey Bailey, Rock, W. Va.

1230. *Proposed by D. A. Lehman, Goshen, Indiana.*

If $a:b = c:d$, and a, b, c, d are positive and in order of magnitude, prove that $a + d > b + c$.

Solved by A. J. Patterson, Wheeling, West Virginia

(1) $\dfrac{a-b}{b} = \dfrac{c-d}{d}$ (by subtraction).

(2) $d(a-b) = b(c-d)$.

(3) $\dfrac{d}{b}(a-b) = c - d$.

Since $a>b$, $c>d$, $a-b$ and $c-d$ are positive. Also $\dfrac{d}{b}$ is a proper fraction. Hence a fractional part of $(a-c)=(c-d)$.

(4) Then $(a-b)>(c-d)$ or $a+d>b+c$.

Also solved by Andrew Sobczyk, Duluth, Minn.; E. T. Morgan, Kirksville, Mo.; M. Freed, Wilmington, California; W. E. Buker, Leetsdale, Pa.; Charles W. Trigg, Los Angeles, California; R. T. McGregor, Elk Grove, California; and D. W. Bailey, Rock, W. Virginia.

1231. *Proposed by F. H. Wade, Lewis Institute, Chicago.*

If BAD is an angle inscribed in a semicircle, with AD as diameter, find the value of $\angle A$ so that AB divides the area of the semicircle into two equal parts.
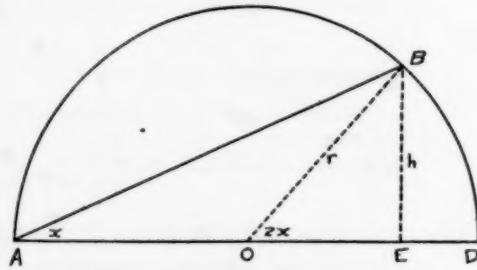
Solved by Charles W. Trigg, Los Angeles, California

Draw the radius $BO=r$, and $BE \perp AD$.

Let $A=x$, then $BOD=2x$.

Since AB divides the semicircle into two equal parts, $\frac{1}{2}$ semicircle $= \triangle AOB + $ sector BOD

Area semicircle $= \dfrac{\pi r^2}{2}$.

Area $\triangle AOB = \frac{1}{2}BE \cdot AO = \frac{1}{2} \cdot r \sin 2x \cdot r = \dfrac{r^2}{2}\sin 2x$.

Area sector $BOD = \dfrac{2x}{2\pi} \cdot \pi r^2 = xr$.

Substituting,

$$\frac{\pi r^2}{4}=\frac{r^2}{2}\sin 2x + xr^2.$$

$$\operatorname{Sin} 2x+2x=\frac{\pi}{2}=1.5708.$$

Using a table of functions of angles expressed in radians by inspection or by expansion of sin $2\times$ by Euler's formula and solution of the resulting equation by Horner's method,

$$2x=0.8316 \text{ radians.}$$
$$x=0.4158 \text{ radians, or } 23° \, 50'.$$

Also solved by W. E. Bulcer, Latsdale, Pa.; A. J. Patterson, Wheeling, W. Va., and D. Moodey Bailey, Rock, W. Va.

1232. *Proposed by Harry Frye, Tullahoma, Tennessee.*

ADE is an equilateral triangle. BC is parallel to DE, with B on segment AD and C on segment AE. $BO = 15$, $OC = 10$, $OE + DC = 100$. Find the area of the triangle.

Solution by W. E. Buker, Leetsdale, Pennsylvania
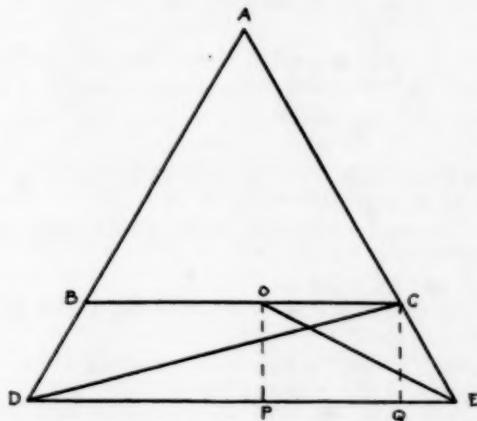
SOLUTION: Drop OP and $CQ \perp DE$. Let $OP = h$. Then $QE = \dfrac{h}{\sqrt{3}}$

$$OE = \left[h^2 + \left(10 + \frac{h}{\sqrt{3}} \right)^2 \right]^{1/2}$$

$$CD = \left[h^2 + \left(25 = \frac{h}{\sqrt{3}} \right)^2 \right]^{1/2}$$

Then, $\left[h^2 + \left(10 + \frac{h}{\sqrt{3}} \right)^2 \right]^{1/2} + \left[h^2 + \left(25 + \frac{h}{\sqrt{3}} \right)^2 \right]^{1/2} = 100$

Squaring and simplifying,

$$\sqrt{\frac{16h^4}{9} + \frac{280h^3}{3\sqrt{3}} + 1300h^2 + \frac{17500h}{\sqrt{3}} + 62500} = \frac{4h^2}{3} + \frac{35h}{\sqrt{3}} - 4137.5.$$

Squaring again, and simplifying, we have $111258.3h^2 + 177323.9h - 17056406.25 = 0$

$\therefore \quad h = 11.6$

Now, $\triangle ABC$ is equilateral, with side 25. Hence, the altitude is $\dfrac{25}{2}\sqrt{3}$.

Then the altitude of $\triangle ADE$ is $\dfrac{25}{2}\sqrt{3} + 11.6 = 33.3$

The area is approximately $369.6\sqrt{3}$

1233.   *Proposed by J. L. Stearn, Washington, D.C.*

Construct a plane triangle having given an angle, the bisector of the angle and the difference of the two sides including the angle.

Solved by D. Moody Bailey, Rock, West Virginia
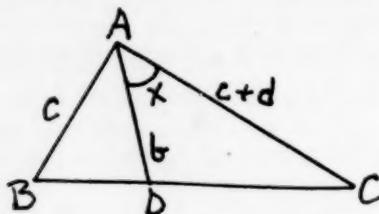
ANALYSIS:

Let $2x$ be the given angle, b the bisector, and d the difference of the two including sides of the angle.

If ABC were the required triangle, we know that $BD/C = DC/c+d$. Let each ratio equal r.

Then $BD = cr$ and $DC = (c+d)r$.

By the law of cosines, $(cr)^2 = b^2 + c^2 - 2bc \cos x$ and $(c+d)^2 r^2 = b^2 + c^2 + 2cd + d^2 - 2b(c+d) \cos x$.

Eliminating the r's from the equations we obtain

$$\frac{b^2 + c^2 - 2bc \cos x}{c^2} = \frac{b^2 + c^2 + 2cd + d^2 - 2b(c+d) \cos x}{c^2 + 2cd + d^2}$$

Solving for c,

$$c = \frac{b - d \cos x \pm \sqrt{b^2 + d^2 \cos^2 x}}{2 \cos x}$$

For the construction derived the positive sign of the radical must be used. The construction of c is not shown but may be accomplished as follows: $d \cos x$ is the base of a *rt.* $\triangle$ having x as the adjacent $\angle$ and d for the hypotenuse. $b - d \cos x$ is then easily obtained. $\sqrt{b^2 + d^2 \cos^2} \, x$ is the hypotenuse of a *rt.* $\triangle$ having b and $d \cos x$ for the legs. If $b - d \cos x$ is added to $\sqrt{b^2 + d^2} \cos^2 x$ and half their sum taken a line is obtained which, if used for the base of a *rt.* $\triangle$ with x as the adjacent $\angle$, forms a $\triangle$ whose hypotenuse is equal to c. After c has been determined the construction of $\triangle ABC$ is easily made.

Also solved by H. Groseman, New York City, and A. J. Patterson, Wheeling, W. Va.

1234.   *Proposed by Israel Rubin, Brooklyn, New York.*

Give a method for finding pairs of consecutive numbers the sum of whose squares is itself a perfect square.

Solution by W. E. Buker, Leetsdale, Pennsylvania

SOLUTION:

The following method does not claim to find all pairs of consecutive

numbers the sum of whose squares is a perfect square, but does enable one to find as many such pairs of numbers as is desired.

Let the numbers be n, $n+1$ and y. Then, $n^2+(n+1)^2=y^2$, or $2n^2+2n+1=y^2(1)$.

The problem reduces itself to the finding of integral solutions of the indeterminate equation (1).

Set $y^2=\left(1-\dfrac{p}{q}n\right)^2$ Substituting in (1) and solving for n, we get

$$n=\frac{2q(p+q)}{p^2-2q^2}\ (2)$$

Now, any values of p and q which, substituted in (2), make n an integer will yield a solution. Obviously, if $p^2-2q^2=1$ (3), then n is an integer. That p and q should satisfy (3) is a sufficient, but not a necessary, condition in order that an n be found which meets the conditions.

Equation (3) is a special case of the Pillian equation and has an infinite number of solutions. To solve it, we start with a pair of values known to be a solution, say $q=r$, $p=s$.

Now if we set $r_1=r+s$, $s_1=2r+s$, we get a set of values satisfying the equation $p^2-2q^2=-1$ (4)

However, if we set $r_2=r_1+s_1$, $s_2=2r_1+s_1$, we get a set of values satisfying (3). Again, if $r_3=r_2+s_2$, $s_3=2r_2+s_2$, then r_3, s_3 satisfy (4); and if $r_4=r_3+s_3$, $s_4=2r_3+s_3$, then r_4, s_4 satisfy (3). This process can be continued indefinitely, giving an infinite number of solutions of (3). Each solution of (3) yields a required value of n, and therefore a solution of the problem.

Proceeding according to the above method, I found the following solutions:

p	q	n	$n1$	y
3	2	20	21	29
17	12	696	697	985
99	70	23660	23661	33461
577	408	803760	803761	1136689

The method can be continued indefinitely. Other methods give

2	1	3	4	5
10	7	119	120	169

Also solved by F. A. Caldwell, St. Paul, Minn.; R. L. Calvin, Youngstown, Ohio; D. Moody Bailey, Rock, W. Va.; and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1230. Phineas High School class and Mathematics Club, Wilmington, California.

1229. Loraine Gibson, Robert Brocker, Billy Christopher, William Mitchell, James Buffington, Harland Edwards, Donald Dwornik, and Woodrow Smith—all of the LaSalle-Peru Township High School, LaSalle, Ill.; Isabelle Miller and E. W. Dalhler, Chadwick, (Illinois) High School.

PROBLEMS FOR SOLUTION

1246. *Proposed by Günther Wünsche, Dresden, Germany.*

In a parallelogram $ABCD$, M lies on AB and N on BC. Through D, lines are drawn parallel to AN and CM. The area of the parallelogram thus formed is to the area of the original parallelogram as AB is to BC.

1247. *Proposed by Andrew Sabczyk, Duluth, Minn.*

Solve for $X: X + \log a\, x = a$

1248. *Proposed by Normal Anning, University of Michigan.*

A triangle with sides a, b, c, medians d, e, f, and area A is given. A second triangle with sides d, e, f, is constructed, and also a third triangle with sides equal to the median of the second. This process is continued indefinitely. Prove that the third triangle is similar to the first. Prove that the sum of all the areas is $4A$, and that the sum of all the perimeters is $4(a+b+c+d+e+f)$

1249. *Proposed by R. T. McGregor, Elk Grove, Calif.*

If $a^2+b^2=7ab$, show that $\log[1/3(a+b)] = \frac{1}{2}(\log a + \log b)$.

1254. *From mathematic contest problems for secondary schools of Hungary in the 1925 competition.*

Determine the number of zeros at the end of 1000!. (1000! is factorial 1000)

1255. *Proposed by Charles Louthan, Columbus, Ohio.*

The combined surface area of a sphere and cube is to be minimized while keeping the combined volume constant. Find the ratio of the radius to the edge.

STRONG ELECTRIC CURRENT MAKES AMEBA BACK UP

Amebae, lowliest of one-celled animals, do not like a too-strong electric current any better than we do ourselves, and if they encounter one will start for somewhere else immediately. How they do it has been studied by William F. Hahnert of the Johns Hopkins University.

An ameba, being only a naked bit of protoplasm, moves by just "ozing along," its living substance flowing in a slow current. When it meets a sudden increase in an electric current, its protoplasmic flow in front stops, and at its rear edge the flow reverses. If the current is weak, this pause is only momentary, and the ameba then keeps on going in the original direction. But if it meets a strong electric "jolt" it reverses itself and leaves the unpleasant neighborhood as fast as it can.

INFLUENCE OF HIGH SCHOOL SCIENCE ON GRADES IN COLLEGE CHEMISTRY

BY GUY A. WEST
New Mexico State Teachers College, Silver City

Recently the question arose as to whether students in first year college chemistry lacked the necessary science background. One professor of chemistry said he preferred that his students come to him without high school chemistry. Another found that his students suffered from lack of scientific concepts and scientific vocabulary. In order to determine more accurately the real situation at our college, the records for the past four years were analyzed.

A tabulation was made of the high school science credits of the students registered for the fall quarter's course in college general chemistry. Six high school sciences were represented, namely: chemistry, biology, physics, general science, physiology, and physiography. The total number of units in all high school sciences was computed for each student. There were in all fifty-nine students for whom complete records were available. A correlation of $0.11 \pm .08$ was found between number of units in high school science and marks received in the fall quarter of college chemistry—a surprisingly low relationship despite the limitations of the study.

Working from the scatter-diagram, the following table was evolved:

Grade in college chemistry	Average number of units in high school science
A	2.21
B	2.46
C	2.05
D	2.10
F	2.20

The foregoing table reveals no discrimination between "A" students and "F" students, with respect to amount of high school science. In fact, there is surprising uniformity in background (in terms of high school science credits) between the groups represented in the five-point grade scale.

Further analysis indicates considerable differentiation between students who had taken high school chemistry and those who had not. The grade point average for the former was 2.62

(approximately B —) while that of the latter groups was 1.81 (approximately C —).

Every student who received "A" in college chemistry had had high school chemistry. The following table shows the average number of units in the various high school sciences for the "A" group and the "F" group in college chemistry:

	"A" students in college chemistry	"F" students in college chemistry
Average No. Units in all H.S. Sciences	2.21	2.20
Average No. Units in H.S. Chemistry	1.0	0.4
Average No. Units in H.S. Biology	0.3	0.9
Average No. Units in H.S. Physics	0.3	0.0
Average No. Units in H.S. General Science	0.07	0.5
Average No. Units in H.S. Physiology	0.3	0.2
Average No. Units in H.S. Physiography	0.3	0.2

The old question of the influence of intelligence cannot be ignored here. Test scores on the Ohio University Psychological Examination were available for fifty-two of the cases studied. A correlation coefficient of $0.38\pm.08$ was found between intelligence test scores and grades in college chemistry at the end of the first quarter. This relationship, however, is somewhat lower than expected in view of other studies. It is to be regretted that college chemistry marks were not assigned by more than one teacher. If more students and more instructors were represented, the marks might be different.

The advocates of general science as an introductory course in high school cannot take much encouragement from these data. Larger numbers might of course show a different tendency. The fact is, however, that the college chemistry course around which this study is centered is taught more as a general science course than as a traditional-type laboratory-textbook course. Magazine articles on the production of rubber, sea divers, geological chemistry sanitation, health, etc., are among the important materials used in the course. A splendid effort has been made to offer a live course in a formerly "dry" subject. And yet, high school general science did not function appreciably stronger than any other science. A point which might be easily overlooked, but which is perhaps important, is the elapsed time since the high school subject was taken. General science courses are usually offered in the earlier years of the high school curriculum. Physics and chemistry are frequent-

ly offered near the end of the senior high school. Direct comparisons of propadeutic values therefore may be subject to some error.

Despite the above considerations there seem to be fairly dependable reasons for concluding that the number of units of high school science a student has taken is of less importance for his success in chemistry at New Mexico State Teachers College than are some other factors, notably intelligence. We note the expected transfer effect (or is it the result of duplication?) of high school chemistry on college chemistry.

SUPPLEMENTARY MATERIAL FOR HIGH SCHOOL PHYSICS

By Donald R. Watson
Citrus Union High School, Azusa, California

No doubt every teacher of physics has approached a lesson trying vainly to recall just where he read that article that gave just the practical application or the latest development wanted for the day's lesson. Science has been moving at such a terrific pace in the last few years that no textbook can be absolutely complete or up to date and no teacher, no matter how much he reads or attends summer and extension courses, can have all the information in mind for the supplementing he desires. The tendency is to stick closely to the text and with what material that may come to mind call the preparation complete.

For several years the writer struggled with the above situation. Just where was that article with the latest data on Cosmic Rays? Or, what are the specifications for the proposed 200-inch telescope? Where may be found the latest on the use of Diesel Engines in airplanes and automobiles? Then follows a hurried search in the few minutes available through magazines at home or in the school library in an effort to find the desired article which was read once, but now almost forgotten. After a while a plan was worked out, so that this might be avoided. Every month when the current issue of a scientific magazine had been read, the articles that might serve as supplements in teaching were jotted down on a card, at the top of which was the date and the name of the magazine. Before each title was placed a letter to designate the part of the course

to which it applied such as: L—light, E—electricity, or Sc.—for science in general. After a number of such cards had been collected, a file was made for each topic so that by turning to the proper file all available material on the subject is found listed.

This sounds as if it were very bothersome and complicated. In practice it is very simple. The record may be made on any type of card and a chalk box is sufficient for the file with tabs on the cards to mark the divisions. Once in operation, 15 minutes a month will keep it up-to-date. If the school does not bind the magazines, best results are obtained if they are kept in a bookcase or locker in the teacher's room. No time is lost then, by going to the library and articles may be gotten during class time if desired.

The magazines filed depend upon those to which the school or teacher subscribes. However, it is suggested that not too many be attempted. Among those available, SCHOOL SCIENCE AND MATHEMATICS, *Scientific American, Scientific Monthly, Science, Nature and Science* and *Invention* should prove satisfactory. Of course, occasional articles in non-scientific journals such as *Harper's* are often worth saving.

After the file is in working order the next possibility is to make it available to the student. This may be done in two ways, first by placing the file and magazines where the students may use them or secondly by assigned reading. The latter method has been used by the writer in the following way. The last half of each period on Friday is used for oral reports on subjects related to the week's work. These articles are given out a day or so in advance either by request or assignment. That is, the student with a special interest is encouraged to read along that line but no one is exempt from the work. Usually, about three reports can be given on one day, averaging ten minutes each. The class is taken in rotation so that in the course of the year each pupil has given from five to ten reports, depending upon the size of the class, while a total of over one hundred subjects have been discussed *by the students*. Topics are chosen that relate to the week's work and students are given some choice as to when and on what they will report. After each is presented, time is allowed for questions and discussion.

This plan has worked splendidly in the writer's classes and has several advantages.

1. The student is made familiar with sources of current science information which he may continue to read after the course is completed.

2. He is brought in touch with the newest developments of science presented in a different manner than that of the textbook.

3. He has a chance to contact the writings and work of the scientific leaders of the day, more and more of whom are endeavoring to present science to the average reader. Millikan, Compton, Heyl, Jeans, and Russell are a few examples.

4. The report day serves as a clearance time for the work of the week. It is difficult sometimes to keep popular discussion from running away with the lesson to the extent that the fundamentals are never covered. With reports ahead, foundations may be laid and then time given for branching out.

5. Most students like it. Those few who object are those who lack ability to express themselves and they are the ones who need it the most.

Such a plan for supplementary material is confined to no one course. Any teacher might use it and numerous variations and improvements no doubt would be suggested.

THIRTY-SECOND MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

By E. O. Bower, *East Technical High School, Cleveland, Ohio*

For the first time in twenty-five years the Central Association of Science and Mathematics Teachers will hold their annual meeting in Cleveland, Ohio, November 25, 26, 1932, at the Cleveland Hotel.

The members of this association in and around Cleveland are leaving nothing undone to make this meeting one of the best in the history of the association.

Speakers of national and international fame have been secured for both the general and sectional meetings. Seldom has it been possible for a program committee to secure so many notables upon one program. You will find upon the general programs Hon. Newton D. Baker of Cleveland (former secretary of war); Dr. Wm. E. Wickenden, President of Case School of Applied Science; Dr. M. Luckiesh, Director, Lighting Research Laboratory, General Electric Company, Nela Park, Cleveland; Dr. Geo. Crile, Cleveland Clinic; Dr. Louis C. Karpinski, Professor of Mathematics, University of Michigan; Dr. Otis W. Caldwell, Teachers College, Columbia University; and Dr. W. W. Hart, Professor of Mathematics, University of Wisconsin.

The general program has not been arranged at the expense of the sectional programs. Those in attendance at the Physics Section will hear Dr. Crile speak upon the subject, "Rôle of Chemistry and Physics in Living Organisms"; Dr. N. Henry Black, Harvard University, will tell about some interesting apparatus from England and Germany, and Mr. G. B. Hamman, East Technical High School, Cleveland, former president of Cleveland Section, Institute of Radio Engineers, will discuss "Radio in High School."

The Chemistry Section will be fortunate in hearing an expert on colloid chemistry, Dr. Harry Holmes, Oberlin College, discuss "Colloid Chemistry as Applied to Medical Research," and Mr. G. T. Franklin, Lane Technical High School, Chicago, tell about Pandemic Chemistry in High School.

Those who are interested in General Science will have the pleasure of listening to David Dietz, Scripps-Howard Science Editor, tell about the "Public Interest in General Science," Mr. Morris Meister, New York University, show some "Demonstration Technique in General Science," and Dr. Wm. L. Connor, Director of Research, Cleveland Public Schools, discuss "Cleveland's Research Program in General Science."

The Biology Program will be exceedingly interesting because Dr. Bradley M. Patten, Baldwin Bird Research Laboratory, will show a micro-movie of the most interesting stages in the development of the heart-beat and establishment of circulation; Mr. Ellis C. Persing, Assistant Professor of Elementary Science, Western Reserve University, will evaluate the Biology Work Book; Dr. C. G. Shatzer, Dean of Wittenberg College, will discuss the Junior Academy of Science; Dr. Ralph Tyler, Bureau of Educational Research, Ohio State University, will present "Tests in Biology"; and Dr. J. Paul Vessiher, Professor of Biology, Western Reserve University, will tell about "Biology Stations in Europe."

The Mathematics Section will be informed about the "Unit Plan and its Results in Plane Geometry," by Miss Edith Sechrist, East Technical High School, Cleveland, Ohio. Dr. Louis C. Karpinski, of Michigan University, will discuss the "Unity of Geometry and Algebra," and Mr. Joseph A. Nyberg, Hyde Park High School, Chicago, Illinois, will show how to "Economize Effort in Teaching Mathematics."

The Geography Section will present Major Clyde H. Butler, Aerial Surveys Inc., Cleveland, Ohio, who will give an illustrated lecture upon "The Value of Aerial Photographs in Teaching Geography," and Mr. Ralph Wensinger, Official Weather Observer, Cleveland Air Port, with an illustrated lecture showing "New Phases of Weather Observation in Connection with Air Transportation."

The new section of the association (continuation of which is subject to the approval of the Board of Directors), The Elementary Science Teachers, have secured pioneers in this field to give their first program.

Dr. Gerald S. Craig, Associate Professor of Natural Sciences, Columbia University, will present "The Place of Science in Elementary Schools," and Miss Mary B. Melrose, Supervisor of Elementary Science in Cleveland Public Schools, will relate the "Program of Elementary Science in Cleveland." Dr. Otis W. Caldwell, Director of Institute of School Experimentation, will give the "Content and Point of View of Elementary Science."

Dinner Meeting—The Association is fortunate in securing as the dinner speaker, Dr. M. Luckiesh, Director, Lighting Research Laboratory, Nela Park, Cleveland, who will address the meeting upon the subject, "Let There Be Light or Scientific Method Is The Only Trustworthy Beacon For Mankind."

In 1910 Dr. Luckiesh came to Nela Park, in Cleveland, where he held the position of physicist in the Research Laboratories until 1920, when he became Director of Applied Science of Nela Research Laboratory. Since 1924 he has been Director of Lighting Research Laboratory.

As a pioneer lighting expert, Dr. Luckiesh has an international reputation, his works being well known throughout the world. The results of his extensive researches in the scientific and psychophysiological aspects and relationships of light, color, lighting, and vision, both from the standpoint of the production and of the utilization of light, are published in the seventeen books and hundreds of scientific and technical articles which he has written. Many of these have been published abroad and make him perhaps the best known man associated with light, color, lighting, and vision in this world.

In addition, D. W. Lott, Assistant Principal of John Adams High School, Cleveland, has planned a very interesting musical program. Those who wish to attend this meeting which will be held in the ballroom of the Cleveland Hotel, Friday, November 25, at 6:30 P.M., should send their reservations to W. O. Smith, Chairman Dinner Meeting, South High School, Cleveland, Ohio, as only one thousand can be accommodated. Tickets will be $1.30 per plate.

The Saturday morning meeting will probably be addressed by Hon. Newton D. Baker, Cleveland, on the subject, "Complete Education."

Mr. Baker, former Secretary of War under President Wilson, is one of the leading educators of today although he is not professionally engaged in it. His ability as a lawyer and statesman is internationally known, but he has always been interested in the educational problems of the youth.

Mr. Baker is at present a member of the Board of Trustees of Western Reserve University, Adelbert College, Cleveland College, and Johns Hopkins University, his Alma Mater. His discussion of a "Complete Education" will be the results of his thinking as a professional man, a statesman, a layman, and an educator.

Prof. W. W. Hart, University of Wisconsin, will give a "Retrospect and Prospect of the Mathematics Section." Dr. Otis W. Caldwell, Columbia University, will speak upon the subject, "Science—Truth or Propaganda."

The entertainment committee has made elaborate plans for the social activities of the wives and friends of the members.

With the above program as an inducement and the work of the publicity and memberships committees we are expecting a large meeting of the Association.

It is regretted that a short biography of all the speakers could not be obtained for publication but we are pleased to present the following as a few of the convention speakers.

HARRY NICHOLLS HOLMES

Born, July 10, 1879, Pennsylvania; educated, Westminster College (Pennsylvania), B.S., 1899, M.S., 1907; Ph.D., Johns Hopkins University,

1907. Professor Chemistry, Earlham College (Indiana), 1907-14; head Department Chemistry, Oberlin College (Ohio), 1914. Chairman, National Research Council's Sub-Committee on Chemistry of Colloids, 1919-25; member, National Research Council, 1923-29; fellow, American Association Advancement of Science; member, American Chemical Society; Gamma Alpha (graduate scientific fraternity), Congregational Church. Former chairman, Division Physical and Inorganic Chemistry, American Chemical Society, and for three terms Councilor at Large. Author: *General Chemistry, Introductory College Chemistry, Laboratory Manual General Chemistry, Elements of Chemistry, Laboratory Manual of Colloid Chemistry,* and thirty published research papers, most of them in colloid chemistry.

DR. LOUIS C. KARPINSKI

Professor of Mathematics, University of Michigan since 1919, has had experience in teaching mathematics extending from district schools to universities. He had charge of the Mathematics Department, Chautauquan Institution, Chautauqua, N.Y., at one time. Under his own name, and also in collaboration with David Eugene Smith and others, he has written much on the History of Mathematics. At one time he was very much interested in the application of calculus in secondary school field. He is interested in the unification of Science and Mathematics and has spoken many times before the Central Association of Science and Mathematics of which he is an honorary life member.

DAVID DIETZ

David Dietz who is to discuss "Public Interest in Science" before the coming meeting of the General Science Section, is Science Editor of the Scripps-Howard newspapers. Mr. Dietz was educated at Western Reserve University, and has done special work in Astronomy at Case School of Applied Science. He began his Science publicity work while still a freshman in college by becoming a member of the editorial staff of a large Cleveland newspaper.

Mr. Dietz is a fellow of the Royal Astronomical Society, a fellow of the American Geographical Society, and a member of the American Association for the Advancement of Science, the British Association for the Advancement of Science, the Société Astronomique de France, the American Astronomical Society, the Ohio Academy of Science, and the Astronomical Society of the Pacific. He is a lecturer in General Science at Western Reserve University.

Mr. Dietz has published *The Story of Science,* a volume intended for the lay reader. This comprehensive work brings the important facts of physics, chemistry, biology, astronomy and geology within the range of the average person's understanding. The American edition is now in its second printing. *The Story of Science* is finding wide use both in England and the United States as a science orientation text for beginning college students.

MORRIS MEISTER

Dr. Morris Meister of the New York Teacher Training College is to discuss "Demonstration Techniques in General Science," before the General Science Section at the coming annual meeting. Dr. Meister is the author of *The Educational Value of After School Science Activities;* a four volume series on Elementary and General Science entitled *Living in a World of Science;* and *The Story of Physics,* a series of articles for children. He is editor of the *Science Classroom.*

Dr. Meister is a charter member of the National Association for Research in Science Teaching, and is Chairman of the Physics Section of the New York Experimental Society. He is an active leader in the work of numerous other professional organizations and special committees in the field of science. Dr. Meister has had wide experience in both secondary and college science teaching. He is at present head of the Department of Science in the New York Teacher Training College, and instructor in the School of Education in the College of the City of New York.

WILLIAM L. CONNOR

CLEVELAND'S RESEARCH PROGRAM IN GENERAL SCIENCE

A broad knowledge of research methods and techniques is likely to be of most value in a special field. William L. Connor brings to the field of general science this knowledge plus wide experience in research in education. His leadership and guidance of Cleveland's Research Program in General Science have been but a small part of his work as Director of the Bureau of Educational Research of the Cleveland schools. "Leaders in Education," furnishes the information that Mr. Connor is a member of Phi Delta Kappa, and is recognized for work done in school administration and supervision, testing, curriculum construction, health education, social studies, and problems in teaching gifted children.

BOOKS RECEIVED

An Arithmetic for Teachers, by William F. Roantree, Jamaica Teacher's Training College, and Mary S. Taylor, New York Teacher's Training College. Revised Edition. Cloth. Pages x+523. 12.5 x 19 cm. 1932. The Macmillan Company, 60 Fifth Avenue, New York. Price $2.50.

Elements of Mechanics, by Henry A. Erikson, Professor of Physics, University of Minnesota. Second Edition. Cloth. Pages xviii+261. 14 x 20.5 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N.Y. Price $2.25.

Applied Colloid Chemistry, by Wilder D. Bancroft, World War Memorial Professor of Physical Chemistry at Cornell University. Third Edition. Cloth. Pages ix+544. 14 x 20.5 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N.Y. Price $4.00.

Experiments in Physics, by Leonard Rose Ingersoll, Professor of Physics, University of Wisconsin, and Miles Jay Martin, Associate Professor of Physics, Milwaukee Extension Center, University of Wisconsin. Third Edition. Cloth. Pages ix+301. 13.5 x 20.5 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N.Y. Price $2.50.

Experimental College Physics, A Laboratory Manual, by Marsh William White, Associate Professor of Physics, The Pennsylvania State College. First Edition. Cloth. Pages xi+283. 14.5 x 23 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N.Y. Price $2.50.

Elementary Mathematical Analysis, by Mayme Irwin Logsdon, Associate Professor of Mathematics, The University of Chicago. First Edition. Volume I. Cloth. Pages xiv+212+32. 14.5 x 23 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N.Y. Price $2.25.

Organic Chemistry, by G. Albert Hill, Professor of Organic Chemistry, Wesleyan University, and Louise Kelley, Professor of Organic Chemistry, Goucher College. Cloth. Pages viii+564. 14 x 21.5 cm. 1932. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

Solid Geometry, by D. Meade Bernard, Head of Department of Mathe-

matics, Robert E. Lee High School, Jacksonville, Florida. Cloth. Pages lix+202. 13 x 19 cm. 1932. Johnson Publishing Company, 8-10 South Fifth Street, Richmond, Virginia. Price $1.24.

Practical Tree Surgery, by Val T. Hanson, Tree Surgeon. Cloth. Pages xiv+101. 13 x 19 cm. 1932. C. C. Nelson Publishing Company, Appleton, Wisconsin. Price $1.50.

Elementary Qualitative Analysis, by J. H. Reedy, Associate Professor of Chemistry in the University of Illinois. Second Edition. Cloth. Pages x+163. 14 x 20.5 cm. 1932. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N.Y. Price $1.50.

The Interpretation of the Atom, by Frederick Soddy of Oxford University, England. Cloth. Pages xviii+355. 14 x 20.5 cm. 1932. G. P. Putnam's Sons, 2 West 45th Street, New York, N.Y. Price $5.00.

Differential and Integral Calculus, by John Haven Neelley, Professor of Mathematics in the Carnegie Institute of Technology, and Joshua Irving Tracey, Associate Professor of Mathematics in Yale University. Cloth. Pages viii+496. 12 x 19 cm. 1932. The Macmillan Company, 60 Fifth Avenue, New York, N.Y. Price $4.00.

Experimental Chemistry for Colleges, by J. Allen Harris, Assistant Professor of Chemistry, University of British Columbia, and William Ure, Assistant Professor of Chemistry, University of British Columbia. First Edition. Paper. 22 Assignments followed by blank pages for Laboratory Report of each Assignment. 192 pages. 18.5 x 26.5 cm. 1932. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N.Y. Price $1.25.

Plane Geometry, by Elizabeth Buchanan Cowley, Teacher of Mathematics, Allegheny Senior High School, Pittsburgh, Pa. 32 pages. 13.5 x 18.5 cm. 1932. Silver, Burdett and Company, 39 Division Street, Newark, N.J. Price 72 cents.

A General Science Workbook, by Charles H. Lake, First Assistant Superintendent of Schools, Cleveland, Ohio; Louis E. Welton, Assistant Principal and Head of Science Department, John Hay High School, Cleveland, Ohio; James C. Adell, Teacher of Science, John Hay High School, Cleveland, Ohio. 29 pages. 20.5 x 26 cm. 1932. Silver, Burdett and Company, 39 Division Street, Newark, N.J. Price 60 cents.

Directed Studies for the Physics Laboratory, A Manual to Accompany Stewart, Cushing, and Towne's Physics for Secondary Schools, by Burton L. Cushing, Head of the Department of Science, East Boston High School. 60 experiments. 168 pages. 18.5 x 26.5 cm. 1932. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price 76 cents.

PAMPHLETS RECEIVED

Vocational Training Costs, A Study of the Unit Cost of Vocational Education in Cincinnati, Ohio. Bulletin No. 162. Trade and Industrial Series No. 47, May 1932. Pages vii+34. 15 x 23 cm. Superintendent of Documents, Washington, D.C.

Biennial Survey of Education in the United States 1928-1930. Chapter XXII. Recent Progress and Condition of Museums by Laurence Vail Coleman, Director, The American Association of Museums. Bulletin No. 20, 1931. 34 pages. 14.5 x 23 cm. Superintendent of Documents, Washington, D.C.

Biennial Survey of Education in the United States 1928-1930. Chapter III. Statistics of City School Systems 1929-1930, prepared in the

Division of Statistics, Emery M. Foster, Chief, with the Collaboration of W. S. Deffenbaugh, Chief, Division of American School System. Bulletin No. 20, 1931. 231 pages. 14 x 23 cm. Superintendent of Documents, Washington, D.C.

Cooperative Marketing Makes Steady Growth. Bulletin No. 8, April, 1932. 62 pages. 15 x 23 cm. Issued by Federal Farm Board, 1300 E Street N.W., Washington, D.C.

Farmers Build Their. Marketing Machinery. Bulletin No. 3, December, 1930. 59 pages. 15 x 23 cm. Issued by Federal Farm Board, 1300 E. Street, N.W., Washington, D.C.

The Mathematical Theory of Vibrating Membranes and Plates, by R. C. Colwell and J. K. Stewart, West Virginia University. A Reprint from *The Journal of the Acoustical Society of America.* April, 1932, Vol. III, No. 4. 5 pages. 16.5 x 24 cm.

The Vibrations of Rods and Plates, by Robert Cameron Colwell, Professor of Physics, West Virginia University. Reprinted from *The Journal of the Franklin Institute,* Vol. 214, No. 2, August, 1932. 15 pages. 16 x 24 cm.

The Collection and Preservation of Animal Forms, by Morris Miller Wells, Ph.D. 72 pages. 15 x 23 cm. 1932. General Biological Supply House, 761-763 East 69th Place, Chicago, Illinois. Price $1.00.

The Story of Writing, prepared under the Auspices of the Committee on Materials of Instruction of the American Council on Education with the Co-operation of the Sub-committee on the American Political Science Association. 64 pages. 12.5 x 19 cm. 1932. Committee on Materials of Instruction of the American Council on Education, 5835 Kimbark Avenue, Chicago, Illinois. Price 25 cents.

The Story of Numbers, prepared under the Auspices of the Committee on Materials of Instruction of the American Council on Education with the Co-operation of the Sub-committee on the American Political Science Association. 32 pages. 12.5 x 19 cm. 1932. Committee on Materials of Instruction of the American Council on Education, 5835 Kimbark Avenue, Chicago, Illinois. Price 10 cents.

The Story of Weights and Measures, prepared under the Auspices of the Committee on Materials of Instruction of the American Council on Education with the Co-operation of the Sub-committee on Political Science Association. 32 pages. 12.5 x 19 cm. 1932. Committee on Materials of Instruction of the American Council on Education, 5835 Kimbark Avenue, Chicago, Illinois. Price 10 cents.

BOOK REVIEWS

Ebene Geometrie, by Albert Gminder, Baltimore, Maryland. First edition. Pages xvi+490. 17 x 24 x 2.5 cm. 771 illustrations. Cloth. 1932. Munich and Berlin: R. Oldenbourg. Price 22 Mk.

The reviewer feels that the teacher of geometry who reads German will cheerfully add this compendium of geometry to his library, for the book is a mine of material, which is selected and arranged according to a definite but novel scheme.

From the preface one learns that the customary presentation of geometry still harks back to Euclid's static view of geometry; whereas it seems that the student of our times is justified in looking for functionality and continuity in geometry. To give the student this new outlook upon geometry the author begins with a review of the necessary arithmetic

and algebra; and follows this up with a thorough discussion of the defini-
tions of geometric figures and the methods of labeling them. By making
the circle the foundation for the body of propositions he is enabled to
stress the idea of functions. In his proofs he aims to produce the con-
tinuous flow from proposition to proposition without the aid of crutches,
such as auxiliary theorems and indirect proofs.

Besides a novel arrangement of theorems and their proofs, one finds
also new material taken from trigonometry, conic sections, maxima and
minima, symmetry, and projective geometry.

It is quite evident that the author belongs to those teachers who be-
lieve in strengthening the teaching of demonstrative geometry through
an emphasis upon the accurate construction of figures. Since his book
contains nearly 800 excellent drawings, he proves that he practices what
he preaches.

Cursory inspection of the book would be facilitated considerably if
the statements of propositions were either printed in heavy type or
numbered. As it is, one has to search for them among the wealth of
material.

F. E. NICOLAI

Physics, for Students of Science and Engineering. Mechanics and Sound,
by A. Wilmer Duff (Editor); *Wave Motion and Light,* by E. Percival
Lewis and revised by R. T. Birge and E. E. Hall; *Heat,* by Charles E.
Mendenhall; *Electricity and Magnetism,* by Albert P. Carman and C. T.
Knipp. Seventh revised edition. 630 illustrations. Cloth. Pages xiv+681.
14 x 21.5 cm. 1932. P. Blakiston's Son and Company, Inc., 1012 Walnut
Street, Philadelphia, Pa. Price $4.00.

It is not to be expected that a textbook of general physics that has
been in continuous use for a score of years and has passed through six
editions will be greatly changed in content or order of presentation. The
text by Duff and others has had a successful career and by frequent re-
vision has followed closely the advance of research. The text is well
adapted for engineering students but is not so suitable for students who
have had little mathematical preparation. Like the majority of other
texts in this field it contains much more material than can be successfully
covered by any class. To aid in selection the less essential topics are
printed in smaller type. Excellent lists of problems and an annotated
bibliography follow each major division.

The seventh edition is practically a repetition of the sixth in the sec-
tions on mechanics, wave motion, heat and sound. The sections on wave
motion and light, originally written by the late Professor E. Percival
Lewis, have been revised by Professors R. T. Birge and E. E. Hall. They
have made a number of important improvements in the treatment of
light by adding the findings of recent research. The greatest change has
been made in the section on magnetism and electricity. Here many topics
have been re-written in clearer form, some new illustrations have been
added, the order and emphasis have been changed for the better, and some
new material has been added. In the opinion of the reviewer a good book
has been improved and brought up-to-date. It will continue to satisfy those
who have been using it, and it merits the attention of others, who want
a comprehensive textbook of general physics for engineering students and
physical science majors.

G. G. W.

Elements of Mechanics, by Henry A. Erikson, Professor of Physics, University of Minnesota. Second edition. Cloth. Pages xviii+261. 14 x 20.5 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York, N.Y. Price $2.25.

The new and enlarged second edition of Erikson's *Elements of Mechanics,* contains two additional articles, one on relativity aspects the other on wave motion, and a valuable new section giving a complete analysis and solution of problems illustrating the application of the principles treated in the text.

Together with the author, I believe that in the teaching of physics the greatest difficulty is encountered in the process of familiarizing the student with the application of the principles to concrete problems and understanding the relation existing between the various physical quantities involved. The addition therefore, of this section is of great value both to the teacher and to the student. Throughout the book the presentation is methodical, the illustrative problems are solved step by step and the significance of the numerical results in terms of physical quantities and unities is emphasized.

I have always felt that the space devoted to the description of instruments in the average college textbook was unnecessarily great and that much of it could find its proper place in a laboratory manual. Yet, in perusing Erikson's *Elements of Mechanics,* I cannot help but feel that the space allotted to the description of important instruments or basic and classical experiments is extremely limited if not altogether missing.

For instance, in connection with the topics of energy and power I did not find any mention of the Prony brake, or in connection with gases the mention or description of any pressure gauge or of Boyle's law apparatus. The book undoubtedly, is best adapted for use in connection with the other University of Minnesota texts on physics, and it will appeal especially to engineering students. The writer recommends Erikson's *Elements of Mechanics* to physics instructors as a reference text and as a valuable addition to their private libraries.

PH. A. CONSTANTINIDES

Out of Doors, A Guide to Nature, by Paul B. Mann, Associate in Education, American Museum of Natural History, Head of Department of Biology, Evander Childs High School, New York City; George T. Hastings, Faculty Member of Nature Camp, Pennsylvania State College, Head of Department of Biology, Theodore Roosevelt High School, New York City. Cloth. Pages x+448. 12.5 x 19 cm. 1932. Henry Holt and Company, One Park Avenue, New York, N.Y.

Much of our scientific knowledge is gained by incidental reading and observation in spare time. This is especially true in biological and earth science. But unless the information is obtained from authentic sources it cannot be relied upon and observation without direction is often useless. This is a book that gives inspiration, guidance in observation, and correct information. It is just what the name implies—an elementary introduction to the study and observation of birds, reptiles, trees, flowers, fossils, stars, and many of the other natural objects and living things found in nature. Children who have access to such books will grow into enthusiastic students of nature and science.

G. W. W.

The Story of Common Things, by Louis Ehrenfeld, Curator of Chemistry in the Museum of Science and Industry, Chicago. Illustrated by Joe Richards. Cloth. Pages v+203. 12.5 x 19 cm. 1932. Minton, Balch and Company, 2 West 45th Street, New York. Price $2.50.

This is a book for the juniors and others who have no knowledge of chemistry. It is a series of most interesting stories on commonplace things told by an authority on the subject who is now devoting much time to making chemistry understandable. The author is Curator of Chemistry in the Museum of Science and Industry, Chicago. This book should be in the library so that girls and boys may read the mysteries of glass, sugar, salt, soap, and other common things. It will inspire them to further study in science.   G. W. W.

How to Understand Chemistry, by A. Frederick Collins. Illustrated. Cloth. Pages xii+321. 12 x 18.5 cm. 1932. D. Appleton and Company, 35 West 32nd Street, New York. Price $2.00.

This is another one of the excellent series of elementary science books by Mr. Collins. It is an elementary textbook of Chemistry suitable for junior high school boys and girls, and it is real chemistry too. It not only gives the fundamental ideas of chemical changes, elements, compounds, chemical measurements, symbols, ionization, and the other essential topics of a first course in chemistry, but there are interesting chapters on thermochemistry, electrochemistry, photochemistry, organic chemistry, and the atomic theory up-to-date.   G. W. W.

HEAR YE!   HEAR YE!

All Members of the
CENTRAL ASSOCIATION OF SCIENCE AND
MATHEMATICS TEACHERS
from Chicago and points north, west and east.

A great re-union and travel party to the Annual Convention
Start at 9:45 A.M., November 24, 1932, from
LaSalle Street Station of the Nickel Plate-Railroad at Chicago
Arrive at Cleveland at 6:15 P.M.

Special arrangements have been made to accommodate all who wish to join along the route. Let's make this the most enjoyable Thanksgiving Day ride we have ever taken. Communicate with

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O N   T O   C L E V E L A N D !